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PHYSICS.—*Melting temperatures of sodium and lithium metasilicates.* F. M. JAEGER. Communicated by A. L. Day.

In studying the heating and cooling curves of the metasilicates of sodium and lithium, I was led by the rapid rate of crystallization of the lithium salt to investigate whether the temperature of change of state of this salt might not prove a favorable constant temperature for the calibration of thermoelements. No good fixed point has yet been found for calibration purposes in the neighborhood of 1200° C., intermediate between the copper point (1082.6°) and the diopside point (1391°).

The material was prepared by mixing the proper quantities of pure lithium carbonate with a specially purified quartz and grinding them together for some hours. After grinding, the mixed powder was melted in a Fletcher furnace, cooled, and again ground for six hours in an agate mortar. This process was repeated three times to insure homogeneity. The analysis of the product showed 67.2 per cent SiO_2 and 32.7 per cent Li_2O, a loss of about 0.5 per cent of Li_2O. A corresponding quantity of the lithium salt was then added to the preparation and the mixture again ground and melted alternately, three times, as before. Subsequent analysis showed again a slight excess of silica and a third portion of lithium carbonate was accordingly added. This preparation when ground and melted three times gave a homogeneous mixture as follows, the lithium being determined as sulphate:

Analysis of lithium silicate

SiO_2	66.60	K_2O	none
(Calculated 66.63 per cent)		Na_2O	0.51
Fe_2O_3	0.016	Li_2O	32.80
CaO	0.034	(Calculated 33.37 per cent)	
FeO	none		

The lithium silicate compound crystallizes beautifully in white glistening needles with perfect cleavage in fine colorless lamellæ, like mica. The microscopic examination showed the preparation to be quite homogeneous except for a few tiny air bubbles between the lamellæ which were probably crowded out in the crystallization of the mass. The crystallization is accompanied by a considerable development of heat and increase of volume. The needles are biaxial with rectangular extinction and very strong birefringence. The direction of elongation of the needles is that of the larger refractive index and the principal plane of cleavage appears nearly parallel to the plane of the optic axis. The angle of the optic axes is rather large. Microscopical examination yielded the following additional data: Refractive index in the direction of elongation of the needles, 1.609; perpendicular to the direction of elongation, 1.589, giving a birefringence of about 0.020, corresponding nearly to augite; direct measurement of the birefringence with the Babinet compensator gave 0.019, in good agreement with the calculated value.

The specific gravity of the finely powdered substance, determined by the picnometer method with xylene (0.8587) gave 2.5203 at 24.9° C.

Three different samples of this preparation were heated successively in the platinum furnace with all the precautions which have been found desirable in the determination of standard melting points in the Geophysical Laboratory. The standard thermoelement C, used by Day and Sosman in the work with the nitrogen thermometer, was used. The results obtained are given on page 51. Prior to these determinations, the thermoelement was examined for homogeneity and found to be free from contamination.

The melting temperature (11,953 microvolts = 1201.8° C.) is as sharply defined as that of diopside and quite as reproducible, as can be readily seen from the experiments themselves.

While the melting temperature of pure lithium metasilicate is sharply defined, the solidifying temperature obtained by cooling down the molten mass is completely dependent upon the rate of cooling, notwithstanding the tendency to crystallize and the

rapidity with which crystallization proceeds. Actual measurements will best illustrate this. In one trial the liquid silicate cooled to 10,914 microvolts where it crystallized suddenly with a rapid rise of temperature to 11,585 microvolts. In a second attempt, the charge cooled to 10,857 microvolts, followed by a rise of temperature to 11,650 microvolts. In a third experiment, the thermoelement was moved within the charge at a temperature corresponding to 11,075 microvolts, whereby crystallization was precipitated at once and the temperature rose to 11,720 microvolts during crystallization. It is therefore clear that the observed temperature of solidification is dependent upon the amount of undercooling and other accidental conditions which chance to surround the charge. It will be noted, furthermore, that the undercooling may amount to more than 1000 microvolts, (approximately equivalent to 100°).

Melting temperatures of lithium silicate

SAMPLE NO.	RATE OF HEATING	ELECTROMOTIVE FORCE
	microvolts per ½ min.	*microvolts*
Sample I	22	11957
	32	11953
		Mean 11955 = 1201.9° C.
Sample II	12	11946
	24	11956
	24	11956
	40	11953
		Mean 11953 = 1201.8° C.
Sample III	11	11947
	26	11956
		Mean 11952 = 1201.8° C.

From these experiments, it again appears clear that solidifying temperatures may have no significance whatever as equilibrium temperatures, but vary with the conditions which chance to surround the melt and with its previous treatment.

This fact probably accounts for the variable results obtained by different observers who have studied the solidifying tempera-

ture of *sodium metasilicate* which crystallizes much more slowly than the corresponding lithium salt and often shows undercooling amounting to 150° C. This may be seen from the following data:

Solidifying temperature of sodium metasilicate

1007° (Kultascheff) 1018° (Wallace) 1055° (Guertler) 1056° (Van Klooster)

A determination of the melting point of an analyzed specimen of a rather pure sodium metasilicate (SiO_2 49.3 per cent, Na_2O 50.6 per cent) made under the same conditions which obtained in the preceding experiments, gave the following values with three different rates of heating: 1086°, 1088° and 1088°. The true temperature of change of state is therefore very nearly 1088° C. (10,600 microvolts in terms of element G, Day and Sosman).

Cooling this particular charge for an observation of the solidifying temperature gave, upon the first trial, 1046°, following undercooling to 1017°; upon the second trial, 1050°. In the third trial, a particle of solid substance was introduced which precipitated crystallization suddenly at 1057°. The solidifying temperature was therefore much below the melting temperature, even under the most favorable conditions of work. It appears to follow from this that the solidifying temperatures of sodium metasilicate given in the literature have little or no significance as determinations of real equilibria. The true melting point is 1088° C.

The refractive indices of the sodium salt are about 1.527 and 1.518 and the birefringence about 0.01.

PHYSICS.—*A method for determining the density of certain solids by means of Rohrbach's solution having a standard refractive index.* H. E. MERWIN, Geophysical Laboratory. Communicated by A. L. Day. To appear in the American Journal of Science.

By means of Rohrbach's solution so prepared that the relation of its density to its refractive index is known, the density of suitable solids between 2 and 3.5 can be determined rapidly and accurately on the total refractometer by finding the refractive index of the solution while fragments of the solid are suspended in it.

The solution saturated with mercuric iodide at 20° and at the density of ordinary orthorhombic sulphur (2.07) has, for concentrations between 2.25 and 3.4, the relation $d = 5.39\ n - 6.0865$, where d is the density and n the refractive index.

ELECTRICITY.—*A study of the current transformer with particular reference to iron loss.* P. G. AGNEW. Communicated by E. B. Rosa. To appear in the Bulletin of the Bureau of Standards.

It has been generally assumed that the ratio of a current transformer always decreases with increasing current, but examples can be given in which the ratio curve slopes in the opposite direction, or even passes through a maximum. The ratio and phase angle performance may be accurately computed from the magnetic data of the core. In nearly all cases the slope of the ratio curve may be qualitatively predicted from the value of the Steinmetz exponent in the equation $W = kB$ where W = total iron loss, B = max. flux, k and c are constants. But the iron losses, particularly at the low flux densities used, depart too widely from such a simple law for accurate work.

The slope of the ratio curve may be accurately computed from the slope of the curve obtained by plotting the core loss against the flux on logarithmic paper. It is proposed that this logarithmic slope, or logarithmic derivative shall be called the "ratio of variation." It is much more useful than an actual exponent. The methods now in use for determining the "exponent" fail to give a true exponent that will satisfy an equation of the form $W = kB$ unless z is a constant. The quantity actually determined by these methods is the ratio of variation.

The wave form of the secondary current of a transformer may be considered to be the same as that of the primary current for even the most precise measurements, as the distortion within the transformer is entirely negligible, as may be shown experimentally. For a good transformer with sinusoidal primary this distortion amounts to less than a part in a million in terms of effective values. While the effect of ordinary variations in wave form on ratio and phase angle may be detected by accurate measurements,

it is too small to be of practical importance, being of the same order of magnitude as the effect of small changes in frequency.

The null methods now in use for the accurate determination of ratio and phase angle all give theoretically currect results, well within the experimental error, so that the accuracy attainable is decidedly greater than is actually required in practice.

GEOCHEMISTRY.—*Minerals and rocks of the composition* $MgSiO_3$–$CaSiO_3$–$FeSiO_3$. ROBERT B. SOSMAN, Geophysical Laboratory. Communicated by A. L. Day.

This paper is a partial report on a study, from the statistical standpoint, of certain rocks and minerals having a composition corresponding to a mixture of the metasilicates of magnesia, lime, and ferrous iron. The method of treatment is already familiar to mineralogists and petrologists through the publications of Vogt.

Although the studies of Vogt have indicated relationships of great importance in the understanding of rocks, they are open to the criticism that the systems treated are too complicated to yield anything more than indications. It should be remembered that the existence of a 2-component or a 3-component system depends upon the properties of the chemical substances entering into it, and upon the range of temperatures and pressures under consideration, and not simply upon the fact that it is made up of two or of three distinct minerals. To treat a mixture of diopside and olivine, for example, as a 2-component system may serve to conceal as many relationships as it brings out. This mixture can be completely discussed only as a part of the 3-component system SiO_2–MgO–CaO.

There are on record analyses of a few rocks and of a large number of minerals that are practically completely made up of the three metasilicates, $MgSiO_3$, $CaSiO_3$, and $FeSiO_3$, with almost no alumina, ferric iron, or other oxides. These analyses, in combination with the experimental data of this laboratory on the system $MgSiO_3$–$CaSiO_3$ form the material for the accompanying 3-component diagram, fig. 1. The evidence is not complete that these three *can* be treated as a 3-component system. But the

existing data indicate that these metasilicates do not react with one another to form any compound that can not be represented in terms of the components, nor do they appear to dissociate to any appreciable extent into their constituent oxides. We may

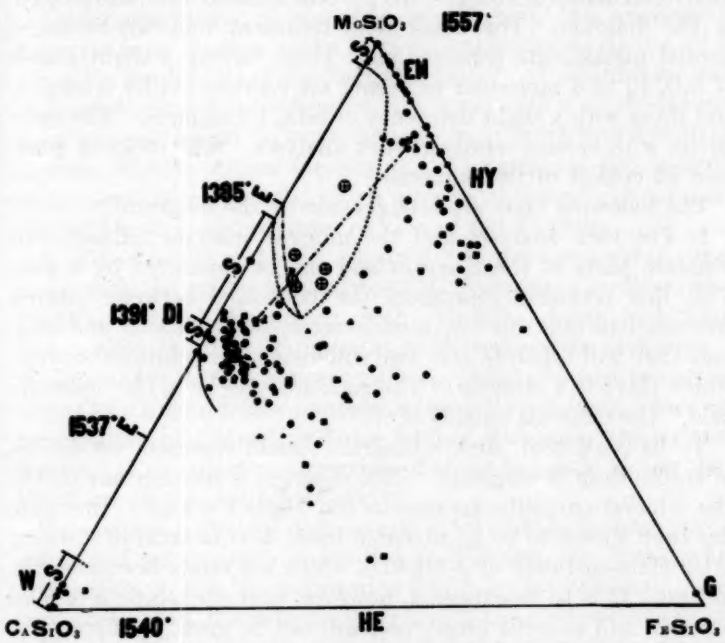

Fig. 1. Diagram of analyses of minerals and rocks in the 3-component system $MgSiO_3$–$CaSiO_3$-$FeSiO_3$. Black dots are mineral analyses; circles are rock analyses. *EN*, enstatite; *HY*, hypersthene; *G*, grünerite (amphibole); *HE*, hedenbergite; *W*, wollastonite; *DI*, diopside; *E*, eutectic; *S*, solid solution.

assume for the present, then, that up to at least 1600° and at ordinary pressures they form a true 3-component system.

The material for the diagram consists of analyses of pyroxenite rocks and pyroxene minerals from the tables of Dana, Clarke, Washington, Wahl, and a number of scattered sources. The data are not claimed to be complete.

The analyses have first been calculated to molecular percent-

ages of the constituent oxides, SiO_2, MgO, CaO, FeO, Al_2O_3, etc. Only those analyses were used in which the sum of SiO_2, MgO, CaO, and FeO exceeded 94 molecular per cent, and in the majority of cases this sum exceeds 97 per cent. The analyses were then recalculated to a basis of 100 per cent metasilicates, and plotted in the diagram. The black dots represent minerals having a normal metasilicate composition. Those having a slight excess of SiO_2 (2 to 4 molecular per cent) are represented by triangles, and those with a slight deficiency of SiO_2, by squares. The open circles with crosses represent rock analyses. The rocks in question all consist of two minerals.

The following facts are brought out by the diagram:

1. The rock analyses and the mineral analyses fall into two separate parts of the diagram and can be separated by a line. This line probably represents the boundary between magma compositions that will form homogeneous solid solutions, and magmas that will separate into two different solid solutions between which there is a eutectic. The rock analyses lie in the "eutectic field," the minerals outside of it.

To be consistent, such a diagram should represent conditions of equilibrium throughout. This diagram is inconsistent in that the mineral enstatite appears in the $MgSiO_3$ corner. Enstatite has been shown to be an unstable form, next in order of stability after clino-enstatite or β-$MgSiO_3$, which has rarely been found in nature. It is to be expected, however, that the relations of solid solution and eutectic proportion will not be greatly different for this false equilibrium, which may indeed have been a true equilibrium under the conditions of formation of these rocks. The same may be true of the neighboring orthorhombic pyroxenes, bronzite and hypersthene.

2. The two types of minerals of which these rocks are made up are in each case the two solid solutions which appear on opposite sides of the "eutectic field." On the upper or $MgSiO_3$ side they are given the names enstatite, bronzite, and hypersthene; on the $CaSiO_3$ side, diopside and diallage.

In the case of one of these rocks, described and analyzed by Williams, the composition of the constituent minerals is given.

This is the analysis marked *p*. Its two constituents, marked *b* (bronzite)and *d* (diopside) should lie at opposite ends of a straight line passing through *p*. The line passing through these three points is almost exactly straight, the small deviation being simply the error of analysis.

Under conditions of complete equilibrium, the analyses of minerals from igneous rocks of these compositions should all lie along the border line of the "eutectic field." If equilibrium were incomplete during solidification, the composition of the constituent minerals might lie some distance away from this boundary, as some of those plotted actually do. The diagram also includes many secondary minerals, which may have almost any composition within the solid solution portion of the diagram.

3. The mineral and rock relations just discussed agree excellently with the experimental data of this laboratory on the system $MgSiO_3$–$CaSiO_3$. Beginning with $MgSiO_3$, Allen and White find a solid solution of diopside in clino-enstatite extending to about 2 or 3 molecular per cent $CaSiO_3$. Mixtures with somewhat more $CaSiO_3$ than this separate into two solid solutions, one of the composition just given, and one having 30.5 molecular per cent $CaSiO_3$. The eutectic proportion of these two falls at the point E (29 molecular per cent $CaSiO_3$).

Corresponding to this 2-phase region we find the 2-phase pyroxenites and websterites. According to Williams, the bronzite has crystallized first in the websterites which he investigated. This fact would place the eutectic line close to the diopside side of the field, agreeing excellently with the determination of its position in the system $MgSiO_3$–$CaSiO_3$, as determined by Allen and White.

Next comes the compound diopside, $MgSiO_3.CaSiO_3$, near which we find grouped a large number of natural diopsides containing varying amounts of $FeSiO_3$, very few of them corresponding exactly to the formula because of the range of solid solution possible. On the $CaSiO_3$ side of diopside the solid solution is found to end at about 52 or 53 molecular per cent $CaSiO_3$. The mineral analyses end here also.

No 2-phase rocks corresponding to the 2-phase region between the two solid solutions of wollastonite in diopside, and diopside in

wollastonite, are known to me. The eutectic composition is at 69 molecular per cent $CaSiO_3$. At the $CaSiO_3$ end occur a number of wollastonites, all lying within the experimentally determined limits of the solid solution (9 molecular per cent $MgSiO_3$).

The diagram illustrates very well how it may become possible to classify minerals and rocks on a physico-chemical basis, starting with chemical complexity as the fundamental character. Such a classification means more to the chemist than to the mineralogist and petrologist, but it is to be hoped that it will throw increased light on the relations of the silicates from both points of view.

MINERALOGY.—*Crystallized turquoise from Virginia.* WALDEMAR T. SCHALLER, Geological Survey. To appear in the American Journal of Science.

A sample of a well crystallized, bright blue mineral from Campbell County, Virginia, sent in for identification by Mr. J. H. Watkins, proved to be turquoise, a species hitherto known only in a cryptocrystalline condition. The mineral forms a secondary botryoidal crust on quartz. The minute crystals composing this crust have a rhombic shape and, like the crystals of chalcosiderite, with which turquoise is isomorphous, are triclinic. As the angles of the two species are very close, the crystallographic elements of chalcosiderite are taken for turquoise: $a : b : c = 0.7910 : 1 : 0.6051$, $\alpha = 92°58'$, $\beta = 93°30'$, $\gamma = 107°41'$. Crystal forms of turquoise: a $\{100\}$; M $\{1\bar{1}0\}$; k $\{0\bar{1}1\}$, large; m $\{110\}$, small; b $\{010\}$, line face. The mean refractive index is about 1.63. The double refraction is high (0.04) and the pleochroism strong, pale blue to colorless.

Analysis and ratios of turquoise

P_2O_5	29.84		2.07
Al_2O_3	31.91	}	3.09
Fe_2O_3	0.18		
CuO	7.87		0.97
H_2O	17.59		9.64
Insoluble	12.57		
	99.96		Density = 2.84

The analysis of the blue crystals leads to the formula $CuO.3Al_2O_3.2P_2O_5.9H_2O$, which, as none of the water is given off below 200°, can be interpreted as $CuOH.6[Al(OH)_2].H_6.(PO_4)_4$.

A comparison with published analyses shows a very close agreement with the composition calculated from this formula. The formula of chalcosiderite should be written analogously with that of turquoise, as $CuO.3Fe_2O_3.2P_2O_5.9H_2O$ instead of with $8H_2O$.

MINERALOGY.—*Quartz and fluorite as standards of density and refractive index.* H. E. MERWIN, Geophysical Laboratory. Communicated by A. L. Day. To appear in the American Journal of Science.

The two minerals, quartz and fluorite, in clear colorless varieties, appear to be the only minerals of wide distribution that have density constant to ± 0.001 and refractive index constant to ±0.0001, regardless of locality. These minerals may therefore be used as standards. The density of quartz at 20° is 2.6495 and its refractive index ω at 20° for sodium light is 1.54425. The corresponding values for fluorite are 3.180 and 1.43385.

MINERALOGY.—*The temperature stability ranges, density, chemical composition and optical and crystallographic properties of the alkali feldspars.* H. E. MERWIN, Geophysical Laboratory. Communicated by A. L. Day. To appear in the American Journal of Science.

Changes in the double refraction of sections of the alkali feldspars, observed during and after heating in the thermal microscope, indicate that both albite and orthoclase appear in two forms, the transition temperature of the low temperature β-form into the high temperature α-form being in both cases about 900°. Sanidine has the optical properties of α-orthoclase and adularia those of β-orthoclase. Microcline appears to be stable to its melting point. Anorthoclase behaves like microcline when heated, except that a slight change in double refraction near 900° has been observed in specimens intergrown with albite. The inversion in both orthoclase and albite is very sluggish even at 1100°. The

optic axial angles of sanidines rich in albite are larger than those of pure orthoclase. The presence of albite in orthoclase raises the density, but apparently not so much as might be expected if no volume change accompanied the mixing; the refractive index, on the other hand, is generally higher than might be expected under these conditions. As the percentage of albite increases the length of the crystallographic axis *a* decreases. The angles in the prism zone and in the zone of the basal and front pinacoids are most affected by this change. Crystals in the same hand specimen often exhibit considerable variation in the value of these particular angles, while other angles remain practically constant. Such variations indicate that the different interfacial angles are not equally sensitive to changes in the concentration of albite in the orthoclase. The crystallographic axis *c* appears to be slightly shorter in adularia than in sanidine.

PETROLOGY.—*A micrometer ocular with coördinate scale.* FRED. EUGENE WRIGHT. Geophysical Laboratory.

This new eyepiece[1] (Fig. 1) consists essentially of a hollow brass cylinder which fits into the microscope tube as an ordinary eyepiece and serves as support for a positive Ramsden ocular in the focal plane of which a finely divided 0.1 mm. coördinate scale is placed. The eyepiece has been designed to serve three purposes (1) that of an ordinary micrometer eyepiece, (2) that of a coördinate ocular for the geometrical analysis of rock thin sections either by the Rosiwal method or by the less accurate method of percentage areas, and (3) for the measurement of the optic axial angle of mineral plates in the thin section provided that at least one optic axis appears in the field of view. In using this eyepiece for optic axial angle measurements it is necessary first to ascertain the equivalent angular value of its different coördinates for the particular lens system of the microscope with which it is to be used; after this has been done, the observer has control over the whole visible field and can measure the optic axial angle of sections which

[1] Made for the writer by R. Fuess Company, Steglitz, Berlin, Germany (cost 35 Marks); also by the Bausch and Lomb Optical Company, Rochester, N. Y. The ruled coördinate scale was furnished in both cases by Swift and Son, London.

show in convergent polarized light either both optic axes or only one in the field of view.[2]

The primary purpose in constructing this coördinate micrometer eyepiece has been to produce an accurate, simple measuring device which covers the entire field of view and with which the

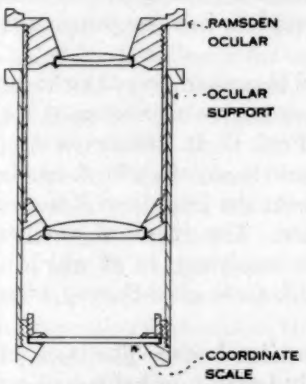

Fig. 1. Section of micrometer ocular

optic axial angles of minerals in the thin section can be measured satisfactorily and geometric analyses of rock thin sections accomplished by either one of the two available standard methods. This eyepiece may well replace the single line micrometer eyepiece which is ordinarily furnished with petrographic microscopes.

PETROLOGY.—*The lavas of Hawaii and their relations.* WHITMAN CROSS Geological Survey.

Introduction.—The writer has undertaken a study of the lavas of the Hawaiian Islands with the dual object of contributing to the petrography of this interesting province and of establishing a basis for testing certain current broad generalizations concerning the genetic relations of igneous rocks. The generalizations in question are: (1) that the so-called *alkali* and *subalkali* groups of

[2] Compare F. E. Wright, Amer. Jour. of Sci. (4), 24: 341. 1907; 29: 423. 1910; 31: 204. 1911.

rocks have a pronounced regional distribution on the earth, which may be appropriately expressed by the names Atlantic and Pacific branches or kindred, and (2) that the chemical differences of these groups are genetically connected with the tectonic distinction made by Suess between regions of subsidence due to radial contraction and zones of folding due to tangential stress. The study is not yet complete but the principal results may be forecast.

In this review of Hawaiian lavas the literature has been carefully studied; an extensive collection of rocks from Oahu and Hawaii, made by Prof. C. H. Hitchcock for the U. S. National Museum and not previously described, has been examined,[1] and also a collection from the islands of Kauai, Maui, and Hawaii, made by the writer. The chemical discussion is based on 36 apparently reliable analyses, 11 of which have been made by chemists of the U. S. Geological Survey, of rocks of the writer's collection.

Character of Hawaiian lavas.—The lavas of the Hawaiian volcanoes are generally basaltic in habit and have received far less attention than they deserve. As indicated by the work of Cohen, E. S. Dana, Lyons, and Silvestri the rocks range chiefly between normal basalts rich in olivine, augite, and highly calcic plagioclase, to pyroxene andesites, either free from or poor in olivine, and containing andesine or more richly sodic plagioclase. There are, however, still more basic rocks than normal basalt, such as tephrite, limburgite, nephelite, and melilite basalt, while one is practically an effusive peridotite similar to wehrlite in composition. At the other extreme there are magmas of essexitic or trachydoleritic character and some andesites nearly free from pyroxene. A soda trachyte described by the writer in 1905 is the most siliceous and feldspathic rock.

The existing analyses evidently do not cover the entire range of rock types but classifying the analyzed rocks in the quantitative system they are found scattered through 3 classes and belonging to 14 subrangs, namely: Nordmarkose-Umptekose (I–II.5.1.4.), akerose (II.5.2.4), andose (II.5.3.4), beerbachose (II.5.3.5),

[1] The writer's thanks are due to Dr. G. P. Merrill for this opportunity.

essexose (II.6.2.4), salemose (II.6.3.4), kilanose (III.5.2.4), camptonose (III.5.3.4), ornose (III.5.3.5), auvergnose (III.5.4.4–5), uvaldose (IV.2_3.1_2.2), unnamed subrangs IV.3_4.1_3.2, and IV.3.1_2.1, wehrlose (IV.1_3.1_2.2).

As to the distribution of the chemical types on different islands it appears that the various volcanic centers are much alike in their products. The collections are too meager and analyses are too few to prove a definite peculiarity for any center. Nephelite-melilite basalts are known on three islands, Kauai, Oahu, and Maui. Strongly feldspathic andesites occur on Oahu, Maui, and Hawaii. Trachyte is known only on Hawaii. Kilauea, the most juvenile volcano of the islands, has produced lavas belonging to 6 different subrangs among the 17 rocks and analysed.

Relations of Hawaiian lavas to the Atlantic and Pacific Kindred.—Through the norms of the 36 analysed rocks of the islands a search has been made for the rocks of the world most nearly identical in chemical composition with each of the Hawaiian types. Washington's tables have been most useful, but many newer analyses have also been compared. For most of the Hawaiian magmas strikingly similar counterparts have been found, tho in some cases the correlated forms are not lavas.

Looking first strictly at the geographic distribution of the similar rocks it is a striking fact that they occur almost all over the world and no one province shows marked resemblance as a whole to the Hawaiian group. It seems noteworthy that comparatively few of the magmas of Hawaiian volcanoes find their nearest relatives in other islands of the Pacific. Few rocks of Tahiti, Samoa, New Zealand, and Australia are closely comparable in composition with types of the Hawaiian group.

With respect to the assignment of the Hawaiian magmas to the Atlantic or Pacific kindred, on composition alone, it certainly appears that the strongest resemblance is to the Atlantic group, yet many of the types have their analogues in the Pacific group. The trachyte of Puu Waawaa on Hawaii is nearest to alkali rocks of Cape Ann, Massachusetts, or of Norway; an andesitic type of the Kohala Mountains, in Hawaii is very nearly identical with an "augite andesite" of Pantellaria and an "åkerite" of Norway; two lavas of Kilauea may best be compared to basalts

of Hesse, or to dolerites, or to "diorites" of New Zealand and Australia; the essexitic andesites of Haleakala find their nearest relatives in "mugearite" (Harker) from the island of Skye, in "trachydolerite" from Cripple Creek, Colorado, in "carmeloite" (Lawson) of California, and among the rhombic prophyries of Norway.

One of the lavas of Kilauea is very close to a "diabase" from Cape Colony, Africa; another is most like a "kersantite" of Thuringia; a third is nearest to a basalt of Cerro San Miguel, Mexico; a fourth may best be compared to a basalt of Pantellaria or one from Cockburn Island. Space is lacking to present further details in this place, but what has been said illustrates the widespread distribution of the magmatic types which are nearest to the lavas of Hawaii in chemical composition.

With respect to conditions of occurrence it is plain that the closest analogues of the Hawaiian rocks occur partly in areas of folded mountain chains, partly in regions of faulting with subsidence, partly in districts where either such characterization of occurrence is little justified. Whatever be intended by the terms Atlantic and Pacific branches or "Sippen" the Hawaiian rocks do not fall clearly into line with either. Among them are some typical "alkali" or "Atlantic" types, some unquestionable "subalkali" or "Pacific" varieties, and a number of intermediate forms.

The Hawaiian magmas tend to show that the generalizations as to geographic distribution or the genetic relations of the "alkali" and "subalkali" groups included in current definitions of the "Atlantic and Pacific branches" or "Sippen" are far from correct. Hence in their present forms they can have no place in a petrographic system.

PALEONTOLOGY.—*Remarks on the fossil turtles accredited to the Judith River formation.* F. H. KNOWLTON, Geological Survey.

The similarity, or often apparent identity, between the turtle faunas of the Judith River and Lance formations has been employed of late, and by several paleontologists, to prove the Cre-

taceous age of the Lance formation ("Ceratops beds"). In the present paper the several species of turtles accredited to the Judith River formation are passed in critical review so far as regards the type locality and formation for each and its subsequent published distribution, both areal and vertical. The following conclusions are reached: (1) The Judith River fauna has had accredited to it at least sixteen species of fossil turtles. (2) Of these sixteen species seven are to be excluded on the sufficient ground that they do not occur in beds of Judith River age. (3) Of the nine remaining species that may have a more or less valid claim to membership in the Judith River fauna, five have their type localities in beds of Judith River and Belly River age and four in horizons above that of the Judith River. (4) Of the five typically Judith River species, four are absolutely confined to these beds, while the remaining one which has an alleged higher range is shown to be probably a composite species, possibly including three species which correspond respectively to the three horizons involved. (5) Of the four species, the types of which came from post-Judith River beds, and which are claimed to range downward into the Judith River, not a single one has a clear title to be so regarded. (6) It is plain, then, that the comparisons that have been made between "Judith River" turtles and those of higher horizons (Lance formation, "Laramie," "Ceratops beds," "Hell Creek beds," "somber beds," etc.), have not been made with species that really belong to the Judith River fauna, but with forms that actually belong to these higher beds. It is not to be wondered at that such a comparison has resulted in showing "identity" and "striking similarity."

ZOÖLOGY.—*Remarks on the nervous system and symmetry of the crinoids.* AUSTIN H. CLARK, U. S. National Museum. Communicated by Barton W. Evermann.

A year ago I published (*American Naturalist*, vol. 44, p. 243) a short note in which I showed how the nervous system of the crinoid might have originated from a nervous system of the annelid-arthropod type concurrently with a loss of directive motion. It remains to be indicated, however, in what way the

complex "dorsal" nervous system of the crinoid may be compared with the relatively simple ventral nervous system of the annelid or arthropod.

The five primary nerve cords arising from the central nerve mass are interradial in position; typically (*cf. Proceedings U. S. National Museum*, vol. 35, p. 87, fig. 1) they very soon divide into two, these two derivatives diverging and uniting with similar derivatives from the adjacent primary nerve cords just within the outer face of the radials; an intraradial commissure connects all the points of union of the branches from the primary nerve cords; five intrabasal commissures connect the two branches of each of the pairs of secondary nerve cords shortly after the division of the primary cords. From the radials single nerve cords (which may, however, exhibit slight traces of a longitudinal division), each composed of half of the two primary interradial cords in the two adjacent interradii, extend outward into the arms.

Now in monocyclic crinoids all the derivatives from the central nervous capsule, or from its extension into the stem, are interradial; and it seems to me that we must regard an interradial position as primitive for the nerve trunks arising from this central capsule. If this view is correct, the dorsal nervous system of the crinoid consists of five primary branches which divide and diverge widely so that they become united by their outer sides to the similar derivatives from adjacent primary branches, each of the five pairs of secondary nerve cords being united by two commissures, one within the basals, the other within the radials. Each one of these five pairs of secondary nerve cords with the connecting commissure is strongly suggestive of the ladder-like ventral nervous system of primitive molluscs, phyllopod crustaceans, nemerteans, peripatus, etc.

This interpretation of the complex nervous system of *Isocrinus* or *Metacrinus* as primarily composed of five interradial nerve pairs which have become united exteriorly is strongly suggested by the nervous system of the fossil genus *Encrinus* as worked out by Beyrich; *Encrinus* has biserial arms, which are more primitive than the monoserial type as seen in *Isocrinus* or *Metacrinus*,

and the derivatives from the primary interradial nerve cords do not join radially, though they approach each other. The intraradial commissures do not extend across the radial gap between the nerve branches, but remain as five separate intraradial commissures joining the secondary nerve cords, just like the intrabasal commissures in the pentacrinites.

The dorsal nervous system of the crinoids is therefore in effect composed of five interradial nerves and their derivatives, each of these nerves being comparable to the single double ventral nerve cord of the arthropod or of the annelid.

Whenever the arm of a crinoid branches, forming an axillary, a curious chiasma occurs within that axillary. The entering nerve at once divides, the two derivatives emerging by the two central canals of the two distal articular faces. Just before they emerge these two branches are connected by a transverse commissure. Oblique commissures run from a point just beyond the division of the main cord to the transverse commissure, crossing each other distally.

This chiasma appears to be a repetition of the nerve branching within the calyx; the two oblique commissures represent the inner branches of the two primitive nerve cords, now fused into one, which have become atrophied through disuse; the transverse commissure represents the intrabasal commissure of the calyx, and is not developed unless the intrabasal commissure is present, being quite independent of the presence or absence of the intraradial commissure.

The supposition that the chiasma within the axillaries is in reality a reduplication of the conditions found within the calyx rather than an original structure peculiar to and developed within the axillaries is strongly supported by the general agreement to be found between the radials and the axillaries. In interpolated division (*cf. Proceedings U. S. National Museum*, vol. 35, p. 113) of the post-radial series or arms, such as is seen for instance in most of the recent comatulids and in the pentacrinite genus *Endoxocrinus*, each axillary supports a pair of ossicles which are the exact equivalent of the first two ossicles beyond each of the other axillaries, and of the first two ossicles beyond the radials.

In its position in reference to the brachials beyond it, therefore, every axillary is essentially a dissociated radial; furthermore, in their proportionate size and shape the axillaries are correlated with the radials and not with any of the ossicles of the post-radial series; this is well brought out in such forms as *Arachnocrinus bulbosus*. There is thus very good reason for believing, aside from the direct evidence available, that the chiasma within the axillaries is in reality a dissociated reduplication of the conditions found within each of the five interradial divisions of the calyx.

The so-called ambulacral nervous system of the crinoids is entirely different from the dorsal nervous system; it is composed of extensions of or branches from the circumoral nerve ring which run out under the ambulacral grooves; these ambulacral grooves are simply radial extensions from the peristomal ring which have carried out with them the nervous structures subjacent to that ring. The circumoral nerve ring and the ambulacral nerves taken together are the equivalent of the supraœsophageal ganglion in the annelid or in the arthropod.

The chief interest in the interpretation of the crinoidal nervous system as composed of five primary interradial nerves and their derivatives lies in the relation which it suggests between the radial and the interradial structures.

From a study of the articulations in the crinoid arm (*cf. American Journal of Science*, vol. 29, p. 40; *American Naturalist*, vol. 43, p. 577) I was forced to the conclusion that the monoserial arm represents the most specialized type, being derived from the biserial by the slipping inward of the two rows of ossicles so that they come to form but a single row, and further that originally the crinoid arms were represented by ten short outgrowths which became laterally united radially; these outgrowths I ventured to suggest as the potential representatives of the ten auricles of the urchins, but developed outside of instead of within the body.

The primary interradial position of the paired nerves greatly strengthens this view; for the derivatives from the primary nerve cords have become greatly divergent, and unite among themselves to form radial nerve cords; as they are most intimately connected with the dorsal part of the ambulacral system it seems that we

must look upon the ambulacral system as primarily double, composed of two similar interradial outgrowths which have moved outward from their primitive interradial position and become united to each other by their *outer* borders. Thus the ambulacra arose as paired interradial structures, the two components of each pair gradually moving away from each other and fusing with those of the adjacent pairs. In the gap thus left various interradial or interambulacral plates have been developed.

It therefore follows that the five fundamental divisions of the echinoderm, the five units of the pentamerous symmetry, are not the five ambulacral series bordered with one-half of the interambulacral series on either side, but *the five interambulacral or interradial areas, plus one-half of each of the adjacent ambulacra.* In this way the fundamentally double structure of the ambulacra is easily explained.

The ventral ambulacral structures must be considered in the same light as the ventral ambulacral nerves; they are merely extensions of the ring systems about the mouth which have grown outward over the supports formed by the double dorsal ambulacral system.

Thus while the double ambulacral skeleton and dorsal nervous system of the crinoids are primarily *interradial* structures, the single processes from the various circumoral systems are primarily *radial*, arising from an enormous development of five radial buds or outgrowths on each of the circumoral structures. The pentamerous symmetry of the crinoids, therefore, is primarily interradial in regard to the dorsal structures, but radial in regard to the ventral.

It might be argued that, as the radial plate (or corresponding structure) is always single, the dorsal ambulacral structure must be primarily single also. The echinoderm skeleton was originally merely a spicular covering developed in the mesoderm of the body wall, comparable to that seen in certain holothurians (tho usually in this group the individual spicules have become curiously specialized) and in general comparable to the skeletons of sponges, red coral, tubipora, etc.; mechanical considerations caused the spicules to become localized in definite areas so that they have

become phylogenetically fixed as definite plates. Any change in the mechanics of an animal with a spicular skeleton we should suppose would be immediately accompanied by either (1) a dissolution of an existing plate or plates, or (2) the sudden union of two or more plates.

In the urchins the presence of the anal opening in the anal area normally occupied by the apical ("sur-anal") plate has resulted in preventing that plate from assembling and has kept it in most cases as a mass of small disconnected plates (*cf. Vidensk. Meddel. fra den naturahist. Forening i Kobenhavn*, 1911, p. 27) which collectively represent the primitive apical plate, the potential homologue of the crinoid stem. Were the anal opening somewhere else we should undoubtedly find a single plate covering what is now the anal area in the urchins just as it does in the crinoids.

The sudden union of several plates is seen in such crinoids as possess three instead of five basals; the three basals collectively are the equivalent of the five collectively; but five have been reduced to three not by a fusion after formation, but by a fusion before formation, really a redivision of the basal-forming area, if it may be thus expressed, resulting from changed mechanical conditions at the time of skeleton formation. In the same way it seems to me that the radials, originally double, have become single through the operation of mechanical factors upon a primitively diffuse spicular skeleton which in most cases has not affected the succeeding plates.

CHEMICAL STATISTICS.—*The consumption of the commoner acids in the United States.* CHARLES E. MUNROE.

On November 10, 1904, I had the honor of calling the attention of the members of the Washington Chemical Society to the fact that as the statistics for chemical manufactures are now being collected and presented by the Bureau of the Census they could be used in solving many problems of interest and value, among them that of ascertaining the principal industries in which a given material has been used and the extent of its use. The results of such a research should prove to be not only of general scientific and economic interest, but also of special value in legislation and

litigation where the rule of "principal use" obtains; in determining tariffs and levying taxes; in fixing freight rates; in manufacturing and other operations where the question of substitution may arise; and in other special instances. In the investigation work of the census itself such data furnishes additional checks on the returns.

I first dealt with sulphuric acid the results being published in *Bulletin 92*, p. 23, "Chemicals and allied products," for 1905;

TABLE I

CONSUMPTION OF MURIATIC OR HYDROCHLORIC ACID

PRODUCTION	1900 Pounds 134,229,012	1905 Pounds 188,538,396
Consumption	1900 *Pounds*	1905 *Pounds*
Bleaching materials	908,000	1,004,000
Chrome tannage	5,000,000	6,000,000
Cleaning façades	3,000,000	4,000,000
Disinfectants	2,500,000	3,200,000
Dyestuffs	6,559,464	7,632,027
Fine chemicals	1,146,697	1,181,078
General chemicals	3,488,000	13,096,827
Glucose making	10,846,828	12,283,466
Glue making	38,186,338	61,795,150
Olive curing	2,500,000	3,500,000
Paper making	3,000,000	4,000,000
Pickling metals	27,000,000	30,000,000
Reducing and refining of metals	15,357,680	24,729,290
Soap making	400,000	393,246
Soldering	4,000,000	3,000,000
Textile manufacture	6,000,000	7,000,000
Washing bone black	1,500,000	1,750,000
Washing sand and clay	1,500,000	2,000,000
All other uses	1,336,005	1,973,312

then salt, published in *Bulletin 83*, p. 82 "Salt" for 1905; and then nitrate of soda published in the *Journal of Industrial and Engineering Chemistry*, Vol. I, May, 1909. An application of the results is shown in "The nitrogen question from the military standpoint" published on pages 225–236 of the *Smithsonian Report* for 1909.

I have been now engaged for several years in collecting the information for chlorhydric, nitric and acetic acids. The methods of procedure followed were those described in the nitrate of soda paper mentioned above. The results obtained are given in the accompanying tables. They cannot be as precise as those for sulphuric acid since the statistics of manufacture embrace all grades, while those for sulphuric acid were so returned that they could be reduced to a common standard. They are believed to represent the best obtainable results and have been so accepted by the several manufacturers to whom they have been submitted.

TABLE II

CONSUMPTION OF NITRIC ACID

PRODUCTION	1900 Pounds 63,084,722	1905 Pounds 108,380,387
Consumption	1900 *Pounds*	1905 *Pounds*
Dyestuffs	1,703,160	663,585
Explosives	35,353,600	82,676,800
Fine chemicals	183,667	1,505,870
General chemicals	353,014	4,256,111
Refining metals	8,000,000	3,000,000
Parting metals	10,221,786	6,810,273
Plastics	2,971,469	4,710,451
All other uses	4,297,826	4,757,297

TABLE III

Consumption of Acetic Acid

Production	1900 Pounds 29,506,021	1905 Pounds 27,875,222
Consumption	1900 *Pounds*	1905 *Pounds*
Dyestuffs	7,000,000	4,000,000
Lead acetate	1,056,584	979,513
Paper making	8,000,000	7,000,000
Textiles	8,000,000	10,000,000
White lead	3,349,809	3,980,150
All other uses	2,099,628	1,915,559

ABSTRACTS

Authors of scientific papers are requested to see that abstracts, preferably prepared and signed by themselves, are forwarded promptly to the editors. Each of the scientific bureaus in Washington has a representative authorized to forward such material to this journal and abstracts of official publications should be transmitted through the representative of the bureau in which they originate. The abstracts should conform in length and general style to those appearing in this issue.

GEODESY.—*Report of the Superintendent of the Coast and Geodetic Survey, showing the progress of the work from July 1, 1909, to June 30, 1910.* 454 pp., 4 maps and 5 progress sketches in pocket. 1911.

The administrative portion of this report recounts briefly the progress of work in field and office for the fiscal year ending June 30, 1910, covering the coasts under the jurisdiction of the United States. It also reports the progress made in surveying and marking the United States and Canada Boundary and the Alaska Boundary, under the direction of the Superintendent as United States Commissioner. Observations to determine the relative force of gravity at 27 stations in 14 States form an important contribution to the gravitation survey of the country. The magnetic survey was extended by making observations at 238 stations on land and at numerous stations at sea. Continuous observations with self-registering instruments were obtained at five magnetic observatories widely distributed over the country. Records of tidal changes were obtained at 15 widely separated stations.

A notable event of the year was the completion, in the instrument shop of the Survey, of a tide predicting machine, elsewhere described in this journal.

The report refers to the important contribution to the science of Geodesy made by the Survey in publications entitled "The Figure of the Earth and Isostasy from Measurements made in the United States" and "Supplementary Investigation in 1909 of the Figure of the Earth and Isostasy," which furnish a determination of the figure and size of the earth of a high grade of accuracy and which, by somewhat novel methods have established the fact that in and around the United States a condition of isostasy exists. This work was laid before the last General Conference of the International Geodetic Association and received formal

recognition when a famous geodesist, F. R. Helmert, arose and congratulated the Americans on having introduced a new epoch in geodesy.

Surveys were made of various uncharted localities in Alaska and excellent progress was made in surveying the waters of the Philippine Archipelago, more than 10 per cent of the estimated general coast line being covered during the year.

Important improvements were made in the construction and use of the long wire drag and its length was increased to 8,400 feet in open water.

The report announces that the policy of orienting charts with the meridian adopted twenty years ago will be continued and a definite programme followed of eliminating the old-style charts and replacing them with a smaller number on the mercator projection. The report is supplemented by six appendixes. Details of field and office operations are given in Appendixes 1 and 2. Appendixes 3–6 are abstracted separately. ISAAC WINSTON.

GEODESY.—*Primary base lines at Stanton, Texas and Deming, New Mexico.* WILLIAM BOWIE. App. No. 4, Rept. Coast and Geodetic Survey for 1910. Pp. 143–171, 5 figs. 1911.

Nickel-steel or invar tapes were adopted by the Coast and Geodetic Survey for the measurement of primary bases in 1906. (See Appendix 4, Report for 1907.) The first primary bases measured in the United States with invar tapes alone are those at Stanton, Tex., and Deming, N. M., in the Texas-California arc of primary triangulation in 1909 and 1910 respectively.

The two bases in question have lengths of 13.2 and 15.5 kilometers. The cost of measuring on the field was $56 per kilometer on the Stanton Base and $39 per kilometer on the Deming Base. Work on the Stanton Base required 17 days, and on the Deming Base 13 days. Measurements with the tape (50-meter) were made on 6 days at Stanton and 3 days at Deming, nearly all in daylight. The probable errors of the resulting lengths are 1/2,561,00 for the Stanton Base and 1/1,961,000 for the Deming Base. These are comparable with those obtained with the best base bars.

A new and very much lighter form of tape stretcher was used on these bases. On the Deming Base five supports were used for each tape length. With this number wind caused little or no trouble. No standardizations were made in the field. Those made at the Bureau of Standards before and after the measurement of each base showed that no one tape changed in length as much as 1/400,000. W. B.

GEODESY.—*Triangulation in California, Part II.* C. R. DUVALL and A. L. BALDWIN. App. No. 5, Rept. Coast and Geodetic Survey for 1910. Pp. 173–429. 40 illus. 1911.

The geographic positions on the United States Standard Datum, of triangulation points between Monterey Bay and Trinidad Head, California, are given with all available descriptions of stations, and 40 sketches, together with a complete index.

The results of the primary, secondary and tertiary triangulation of 1906–07, executed principally to determine the effect of the earthquake of 1906 on the old triangulation, are here published in full for the first time. Along with the newly determined position of each of the 61 old points is given the position resulting from observations made before the earthquake. For a number of the old points it was possible to compute separately the observations made before the earthquake of 1868, and for these the three corresponding positions are placed together. A comparison of these positions and a discussion of the corresponding displacement was published in Appendix No. 3, Coast and Geodetic Survey Report for 1907. ("The Earth Movements in the California Earthquake of 1906," by J. F. Hayford and A. L. Baldwin.) C. R. D.

GEODESY.—*The measurement of the flexure of pendulum supports with the interferometer.* W. H. BURGER. App. No. 6, Rept. Coast and Geodetic Survey for 1910. Pp. 431–449. 5 figs. 1911.

The interferometer was adopted by the Coast and Geodetic Survey for determining the flexure of the pendulum supports in 1907. Preliminary investigations were made by the author under the direction of Mr. John F. Hayford with apparatus designed and constructed in the instrument division of the Survey, under the immediate direction of Mr. E. G. Fischer. The instrument and methods are here described and illustrated in sufficient detail to enable one to use them successfully.

This interferometer is a modified form of the one described in "Light Waves and Their Uses," by A. A. Michelson. It has given excellent results at more than sixty field stations in the United States during the past three years and at the base station at the Sur ey office, while the pendulums were being restandardized. This is believed to be the first time that the flexure of the pendulum support has been determined satisfactorily at field stations by this method. WILLIAM BOWIE.

METEOROLOGY.—*Some causes of variation in the polarization of sky-light.* HERBERT H. KIMBALL, Weather Bureau. Journal of the Franklin Institute, April, 1911.

A summary is given of the observations made by the author in Washington between December, 1905, and May, 1910, and at various other stations of the Weather Bureau between July and October, 1910. It treats mainly of the relation of sky polarization to the meteorological conditions, with special reference to atmospheric transmissibility for solar rays. Most of the observations have been made in connection with pyrheliometric measurements of the intensity of solar radiation.

Accepting Rayleigh's theory that the polarized component of sky light is due to the scattering of the solar rays by very small particles, principally the gas molecules of the atmosphere, it follows that a depletion of the solar rays due to scattering by large particles, such as dust, smoke, and water drops, should be accompanied by a decrease in the percentage of polarization. The observations show that this is the case, but that loss of solar radiation intensity due to absorption by aqueous vapor has no effect upon the polarization.

When air currents of different temperatures, or different degrees of saturation, and, in consequence, of different densities, are in juxtaposition, discontinuous surfaces are formed which reflect and disperse light incident upon them, resulting in a diminution of both the intensity of the solar radiation and the polarization of sky light as measured at the surface of the earth. The observations show that such conditions are usually followed by cloudiness and rain. It would therefore seem that a measurement of the polarization of sky light should give an early indication of any disturbance that may exist in the atmosphere. This would probably be the case were it not for the fact that sky polarization is modified by the amount of light reflected from the surface of the earth and from clouds, and also from dust and haze in the lower layers of the atmosphere.

The distance of the neutral points of Arago and Babinet from the anti-solar point and the sun, respectively, increase as the percentage of polarized light decreases. Since these distances may best be measured when the sun is just below the horizon, the irregularities due to reflection from the surface of the earth may be largely eliminated. However, since pyrheliometric measurements are only influenced by atmospheric conditions along the path of the incident solar beam, they are believed to offer a more promising index to atmospheric conditions than do any form of polarization observations. H. H. K.

METEOROLOGY.—*Levels of maximum and minimum cloudiness.* W. J. HUMPHREYS. Bulletin of the Mount Weather Observatory, 4. 1911.

The formation of fogs is caused mainly by the cooling of the surface of the earth through radiation, and hence the surface of the earth itself is one level of maximum condensation. The next level of maximum condensation is that of the cumulus cloud, and is limited in elevation by the vertical temperature gradient of the atmosphere. The decrease of temperature with elevation for the first three kilometers usually is far less than the adiabatic rate. Hence, under these conditions, convection can not extend very high, and therefore cumulus clouds commonly are phenomena of the lower atmosphere and of frequent occurrence. The next and only other level of maximum condensation is just beneath the isothermal region where the cirrus cloud prevails. Since the temperature at this elevation ceases to decrease with altitude therefore it is the limit of vertical convection, and any clouds brought to this level by long continued storms must spread out and not go up higher. The limit to convection and the swift winds of the upper cloud region spread the cirri over extensive areas, and hence they are more frequently seen than are those of the next lower levels that are more limited in extent.

At middle latitudes the levels of maximum condensation are, roughly: (1) *Fog level*, surface of the earth or water. (2) *Cumulus level*, 1 to 2 kilometers above the surface. (3) *Cirrus level*, 8 to 10 kilometers above the surface.

The corresponding approximate levels, or, preferably, regions of minimum condensation, are: (1) *Scud region*, 100 to 300 meters elevation. (2) *Alto-stratus region*, chiefly 4 to 6 kilometers above the surface. (3) *Isothermal region*, usually 11 kilometers or more above the surface. W. J. H.

METEOROLOGY.—*Origin of the permanent ocean highs.* W. J. HUMPHREYS. Bulletin of the Mount Weather Observatory, 4. 1911.

The circulation of the atmosphere between the warm equatorial and the cold polar regions, together with the rotation of the earth, causes the prevailing winds at higher latitudes than about 33° to blow from west to east, and the tropical winds to blow from east to west. The former have an angular velocity about the axis of the earth greater than that of the earth itself, and therefore press up toward the equator, while the latter have a smaller angular velocity than the earth and conse-

quently tend to slide down toward the pole. Hence there are two belts of high barometric pressure surrounding the earth; one at about 32° S, and the other about the same latitude north. Both are well marked on the oceans, but, owing to great temperature variations, are practically obliterated over continents.

But even on the oceans the belts are not uniform. The northern belt has one region of maximum pressure, with closed isobars, just west of southern California, and another in the eastern Atlantic. The southern belt has three regions of maximum pressure; one just west of Chile, another west of southern Africa, and a third west of Australia. Each of these five regions of maximum pressure is essentially permanent, accompanied by fair weather, and surrounded by gentle anticyclonic winds.

At each of the five places of maximum barometric pressure, but nowhere else, the belts of high pressure are crossed by cold ocean currents. These pressure maxima, therefore, are due to the combined influence of the mechanical action of the oppositely directed winds north and south of them and to the low temperature of the cold ocean currents, and are located where the sum of the two influences has its maximum values.

The original paper contains several explanatory figures. W. J. H.

METEOROLOGY.—*On the relation between atmospheric pressure and wind.* J. W. Sandström. Bulletin of the Mount Weather Observatory, **3**: 275–303. 1911.

A difference in barometric pressure between two neighboring places at the same level necessarily must start the wind blowing from the place of higher towards the place of lower pressure. But the direction of flow is modified by the rotation of the earth, and by frictional resistance. There are, then, three forces acting on a moving mass of air. A gravitational force proportional to and in the direction of the barometric gradient, (2) a force, clockwise in the northern hemisphere, at right angles to the instantaneous direction of the wind and proportional to the sine of the latitude, (3) a frictional resistance numerically equal and opposite in direction to the resultant of the other two.

On applying these facts to special cases the friction is found to be divisible into two portions, one of which is that of the wind on the surface of the earth, and the other that between the wind and the upper currents of air, which usually differ from the surface winds both in direction and speed. The author also shows how these forces may so combine as to cause the wind to follow a sinuous path.

The original paper is abundantly illustrated by meteorological charts of northern Europe. W. J. Humphreys.

TERRESTRIAL MAGNETISM.—*Results of magnetic observations made by the Coast and Geodetic Survey between July 1, 1909, and June 30, 1910.* R. L. FARIS. App. No. 3, Rept. for 1910, pp. 71–141. 1911.

This publication contains the results of magnetic observations made on land and at sea by the Coast and Geodetic Survey in the prosecution of the magnetic survey of the United States and outlying territories during the fiscal year ended June 30, 1910, including the determinations of the magnetic elements in 39 States and Territories. The results on land are tabulated by States and in the order of increasing latitudes of the stations. During the year observations were made at seventy-five (75) old stations to ascertain the secular change of the magnetic elements. Results of observations on the Atlantic and Pacific oceans and in the Philippines are grouped in separate tables. The latter portion of the report is devoted to the descriptions of land stations, including their permanent markings and true bearings from them to permanent objects, which are of use to local surveyors, especially where true meridian lines were established in conjunction with the magnetic work. R. L. F.

ELECTRICITY.—*The electrical conductivity of commercial copper.* F. A. WOLFF and J. H. DELLINGER. Bulletin Bureau of Standards, 7: 103–126. 1911.

A reliable average value for the conductivity of the copper furnished for electrical uses was desired by the American Institute of Electrical Engineers, to be used as the basis of new tables, to replace their old *Copper Wire Table* of 1893. The Bureau of Standards was asked to obtain the data, and copper samples from representative sources were investigated. Besides the samples measured extensive data were obtained from a large manufacturing company. The mean of the data, representing tests on more than 100,000,000 pounds of copper, was practically the same as the value previously assumed for the resistivity of *annealed* copper, in the preparation of wire tables and in the expression of per cent conductivity, etc., viz., *0.153022 ohm per meter-gram at 20° C.* This value is to be called the "Annealed Copper Standard."

The conductivity of hard-drawn wire of about 2 mm. diameter was found to be less than the conductivity of annealed wires by a mean value of 2.7 per cent. The difference between the conductivity of annealed and hard-drawn wires increases as the diameter decreases. The highest conductivity found was that of a wire drawn directly from a mass of native lake copper, viz., 101.71 per cent of the conductivity of the

'Annealed Copper Standard." The advantages of ohms per meter-gram as a unit of resistivity are stated. The desirability of an international standard of copper conductivity is urged. J. H. D.

ELECTRICITY.—*The temperature coefficient of resistance of copper.* J. H. DELLINGER. Bulletin Bureau of Standards, 7: 71–101. 1911. Abstracted in the Journal of the Franklin Institute, 170: 243. 1910.

Standard values for the temperature coefficient of copper have varied greatly, and anaccurately determined value on representative samples was needed. Samples were investigated from 14 of the leading copper refiners and wire manufacturers in the United States, Germany, France, and Austria. The measurements were of especially high relative accuracy, as the wires were all compared against a copper auxiliary wire in the same oil bath. The principal result was the discovery of a proportional relation between conductivity and temperature coefficient, which holds substantially for samples chemically different, and holds within the errors of measurement for differences in conductivity due to differences in hardness. The change of resistivity per degree C. of a sample of copper is 0.000598 ohm per meter-gram or 0.00683 micro-ohm per centimeter cube, these constants holding for any temperature of reference and any sample of copper.

Bending and twisting a wire produce no material change in the temperature coefficient, although they increase the resistance. It may therefore be assumed with greater confidence than heretofore that the temperature coefficient of a copper wire is not changed by winding. In virtue of the proportionality between temperature coefficient and conductivity, the measurement of temperature coefficient may in certain cases be substituted for the direct measurement of conductivity.

The relation of resistance to temperature was found to be linear, for the temperatures investigated, 10° C. to 100°C. If this relation actually held continuously down to zero resistance, there would be a set of different temperatures, all higher than −273°C., at which the resistances of copper samples of various conductivities would vanish, and these "inferred absolute zeros" of resistance are sometimes used as an aid in remembering the temperature coefficient. But this investigation indicated nothing of the actual resistance of copper at very low or very high temperatures.

The proportionality between temperature coefficient and conductivity has been confirmed by results obtained at the Reichsanstalt. J. H. D.

ELECTRICITY.—*A device for measuring the torque of electrical instruments.* P. G. AGNEW. Bulletin Bureau of Standards, 7: 45–48. 1911.

The device consists essentially of a dynamometer of the pendulum type. A needle is attached to the bob of the pendulum to serve as a pointer which swings closely over a scale consisting of 153 concentric circles engraved on the concave surface of a very shallow spherical bowl of a radius of curvature of one meter. The bob is suspended by a silk fiber at the center of curvature of this scale, which reads tangents of angles directly, the divisions being approximately 1 mm. and hence indicating angles whose tangents are 0.001, 0.002, etc. The force to be measured (always horizontal) is transmitted to the bob by a second fiber attached at its center of mass. The force in grams is then equal to the product of the weight of the bob into the number of divisions deflection. The range may be changed by attaching extra weights to the bob.

In measuring the torque of a deflection instrument—for example a voltmeter—the horizontal thread is fastened to the pointer at a convenient distance from the pivot and the voltmeter moved horizontally until the desired deflection is produced. We then have

$$\text{Torque} = \text{arm} \times \text{weight} \times 0.001 \times \text{reading in divisions.}$$

In the case of a watthour meter it is necessary only to attach the thread to the edge of the disk, apply current and voltage to the meter, and allow the thread to wind upon the disk as far as it will. Under proper conditions an accuracy of 0.1 per cent may be obtained. The torques of some types of instruments have been found to range as follows: D. C. voltmeter 0.3 to 2.1 gram-cm.; D. C. ammeters 0.2 to 0.9 gram-cm.; A. C. watthour meters 3.0 to 7.8 gram-cm. P. G. A.

RADIO-TELEGRAPHY.—*Quantitative experiments in long distance radio-telegraphy.* L. W. AUSTIN, U. S. Naval Wireless Telegraphic Laboratory. Bulletin Bureau of Standards, 7: 315–363. 1911.

The U. S. naval wireless laboratory during the winter 1909–1910 and the spring and summer of 1910 carried on quantitative measurements on the relation between the currents in the sending and receiving radio-telegraphic antennas. This work was taken up in connection with the testing of the wireless set at the Brant Rock station and those of the scout cruisers *Birmingham* and *Salem*. The Brant Rock station devel-

oped 60 kw. Its antenna was an umbrella 420 feet at top, about 170 feet at bottom with a capacity of 0.0073 microfarad. The scouts' sets were of 10 k.w. and their antennas were flat-topped, 130 feet high, with a capacity of 0.0018 microfarad. During a part of the test this was increased to 0.0025 by extensions slanting downward fore and aft of the regular antenna. The chief wave lengths used were 1500 meters and 3750 meters on the part of Brant Rock, and 1000 meters and 3750 meters on the ships.

In the July, 1910, test which was considered the most reliable the measurements were carried on up to nearly 900 nautical miles between the ships and to about 1200 miles between Brant Rock and the *Birmingham*.

The receiving measurements for the shorter distances were made in part by means of thermoelements in the antenna. At the greater distances the method of telephone shunt readings in connection with the electrolytic detector was used, the value of the received antenna current being derived from the shunt reading by means of comparison readings taken on a thermoelement in the antenna at the shorter distances.

In addition to these measurements already mentioned subsidiary observations were made between Brant Rock and a small station 11 miles away on the effect of height of a flat top antenna on sending and receiving and also on the effect of wave length.

The results are briefly as follows:

(*a*) Over salt water the electrical waves decrease in intensity in proportion to the distance as found by Duddell and Taylor. In addition they are subject to an absorption which varies with the wave length and which may be expressed mathematically by the term e^{-Ad}.

The complete expression for the received current is then

$$(1) \quad I_R = \frac{K}{d} e^{-Ad}$$

where I_R is the received antenna current, d the distance, and K and A constants.

This is true in general for day transmission. The absorption at night is entirely irregular varying from zero to the day value, but is on an average much less during the winter than in summer. The great variations in night absorption make useless all attempts to judge the quality of wireless apparatus from night distances. For this purpose only observations on the average day range have any value. Variations also appear to occur during the daytime, but these are probably in general

small. (*b*) The received antenna currents between two stations are proportional to the product of the heights of the sending and receiving antennas and inversely proportional to the wave length, provided the antenna resistances remain constant. (*c*) Taking account of the influence of antenna height and wave length equation (1) may be extended and a general day transmission formula written as follows

$$(2) \quad I_r = 4.25 \frac{I_s h_1 h_2}{\lambda d} e^{-\frac{0.0015\ d}{\sqrt{\lambda}}}$$

When I_s is the sending antenna current, h antenna height and λ the wave length. The currents are given in amperes and all lengths in kilometers. From this it would appear that it is advisable to rate stations according to the magnitude of the antenna current, or perhaps better, according to the product of the current into the height. L. W. A.

CHEMISTRY.—*The behavior of high-boiling mineral oils on heating in the air.* C. E. WATERS. Bulletin Bureau of Standards, **7**, 365–376, 1911. Journal of Industrial and Engineering Chemistry, **3**: 233. 1911.

The oils were heated to 250° for three hours in Erlenmeyer flasks which were placed in a special air-bath so arranged as to secure free diffusion of air into them, as well as to allow the escape of volatile portions of the oils. After cooling, the contents were diluted with petroleum ether and next day the insoluble "asphalt" was filtered off and weighed. The insoluble matter was shown to be an oxidation product. The amount formed was apparently independent of the amount of oil evaporated. The latter, and also the amount of varnish-like coating on the walls of the flasks, varied widely, but the amount of insoluble matter was fairly constant.

There seemed to be some evidence of catalytic action which influenced the amount of insoluble and "varnish" formed. These were both greater in amount when a second lot of oil was heated in a flask which had not been cleaned after one heating.

Three different oils were heated also in tubes of the same dimensions made of glass, brass, chrome-vanadium steel, vanadium steel, cold-rolled steel, cast iron and a steel containing 0.8 per cent carbon. For two of the oils the percentages of insoluble formed were about the same in all of the tubes, except those of brass, where the amount was much greater. The third oil yielded less insoluble in the brass tubes than in those of glass, and very much greater amounts in the chrome-vanadium

steel tubes than in any of the others. This oil contained approximately 0.5 per cent fatty oil, while the other two were straight mineral oils.

C. E. W.

CHEMISTRY.—*The determination of manganese in vanadium and chrome-vanadium steels.* J. R. CAIN. Journal of Industrial and Engineering Chemistry, July, 1911.

The bismuthate method for manganese gives high results in vanadium or chrome-vanadium steels because some of the chromium and all of the vanadium are also oxidized and react with the ferrous solution used to reduce the permanganic acid. The Ford-Williams method gives high results because of occlusion of chromic acid by the precipitated manganese dioxide. The present method eliminates these sources of error by precipitating the chromium and vanadium out of a sulphuric acid solution of the steel by cadmium carbonate[1] and determining manganese in the filtrate by the bismuthate method after adding nitric acid.

J. R. C.

CHEMISTRY.—*The determination of vanadium in vanadium and chrome-vanadium steels.* J. R. CAIN. Bulletin Bureau of Standards, 7: 377, 1911; Journal Industrial and Engineering Chemistry, 3: July, 1911.

Various errors in the usual methods for determining vanadium in steel are pointed out and in a few cases methods for correcting or eliminating these are indicated. A new method based on precipitation of the vanadium by cadmium carbonate followed by electrolysis, reduction and titration, is described. J. R. C.

ELECTROCHEMISTRY.—*The relation of surface action to electrochemistry.* HARRISON E. PATTEN, Bureau of Soils. Transactions of the American Electrochemical Society, 19. 1911.

A mathematical and illustrated treatment which may be summarized as: (1) A definition of surface tension as the first derivative of surface energy with respect to surface change. (2) A consideration of the general equations of surface changes following the treatment given by J. Willard Gibbs. (3) An extension of these equations with the assistance of a cyclic process to surfaces having an electric charge. (4) The appli-

[1] Jour. Ind. and Eng. Chem., 3: July, 1911; also Bull. Bur. Standards, 7: 377. 1911.

cation of the general equation developed in the third section to electro-capillary phenomena, to migration of suspended particles, and to electric osmose. (5) The relation of absorption phenomena to electro-capillary phenomena, to settling of suspensions, to formation of electrolytic deposits, and to the behavior of disperse systems in general.

H. E. P.

AGRICULTURAL CHEMISTRY.—*The color of soils.* W. O. ROBINSON and W. J. MCCAUGHEY. Bulletin Bureau of Soils, No. 79. Pp. 29. May, 1911.

This bulletin treats of the causes of difference in color, particularly of the red and yellow soils. It is concluded from the results of the iron determinations and the mechanical analysis of twenty typical red and yellow soils that the color is due to a colored film, mainly of iron and aluminum oxides and organic matter, surrounding the soil particles. A thin film gives a yellow color and a thick film a red color. Theoretical considerations indicate that the iron oxide in various soils must be in nearly the same condition of hydration. Mineralogical examination shows that in general the minerals in the red soils have been subject to more weathering than those of the yellow soils. Red soils are in general older than yellow soils, and certain chemical characteristics show them to be better drained.

W. O. R. and W. J. McC.

AGRICULTURAL CHEMISTRY.—*The solubility of lime in aqueous solutions of sugar and glycerol.* F. K. CAMERON and H. E. PATTEN, Bureau of Soils. Journal of Physical Chemistry, **15**: 67. 1911.

(1) Solubility isotherms for lime in solutions of sugar and of glycerol at 25° have been determined by direct analysis of the liquid phases. (2) The solid phase in the system lime-sugar-water is one of a series of solid solutions, with calcium hydroxide a limiting case. (3) The solid phase in the system lime-glycerol-water at 25° is always calcium hydroxide. (4) The increase in solubility of lime in aqueous solutions of glycerol over that in pure water is directly proportional to the concentration of glycerol.

F. K. C. and H. E. P.

AGRICULTURAL CHEMISTRY.—*The theoretical basis for the use of commercial fertilizers.* FRANK K. CAMERON. Journal of Industrial and Engineering Chemistry, **3**: No. 3, March, 1911.

Abstract of remarks made before the Division of Fertilizer Chemists

at the Minneapolis meeting of the American Chemical Society. It was pointed out that soils behave as individuals, owing to the number and interdependence of the properties of the soil mass and its individual components. Crop production, therefore, is the result of many factors, natural and artificial, but all mutually dependent. Each of the artificial methods of control, tillage, crop rotation, and fertilization, affects all the factors; consequently, no simple theory of fertilizer action can satisfactorily explain the facts. With intensive methods of cultivation, fertilizers are effective on all kinds of soils, more so on the naturally better soils. Materials other than those containing the traditional plant foods may become valuable fertilizers if they satisfy commercial requirements. F. K. C.

AGRICULTURAL CHEMISTRY.—*Effect of a second solute in adsorption by soils and in leaching of soluble salts from soils.* HARRISON E. PATTEN. Journal of Physical Chemistry, **15**. 1911.

A higher concentration of phosphates may be obtained when weak solutions of salts ordinarily used as soil amendments (potassium chloride, potassium sulphate, potassium and sodium nitrates, or potassium carbonate) are passed through the soil than can be obtained by the use of distilled water alone. This effect is not simply a question of the "solubility" of phosphate in water or in the solutions used for percolation, since the volume of liquid held in contact with the soil material is in all cases far greater than that required to dissolve the small amounts of phosphates and of other salts present. The effect is evidently due to a disturbance of the equilibrium between the soluble material retained by the soil and the soil solution. This disturbance having been produced the soil system tends to readjust itself, giving a *very roughly* steady value for the concentration of the leachings with respect to phosphate.

The bearing of this on the use of soil amendments is that it opens questions as to the actual functions of different salts when added to promote plant growth. It appears possible that the addition of, e.g., a nitrate or a chloride to the soil may benefit a plant by liberating phosphate, as well as by the addition of the salt itself for plant use. In addition must be considered the effects of the liberated phosphates and of the added soil amendment upon the physical structure and condition of the soil. H. E. P.

AGRICULTURAL CHEMISTRY.—*The effect of moisture and of solutions upon the electric conductivity of soils.* R. O. E. DAVIS. Transactions of the American Electrochemical Society, **17**: 391–403. 1911.

Experiments on the conductivity of several types of soil under various conditions are described. The relation of conductivity of a soil to the corrosion of iron is pointed out. From the measurements of soil resistivity the conclusions are drawn: (1) That in the dry condition the soil offers a high resistance to the passage of the electric current. (2) That at a depth of two feet or more the conductivity remains roughly constant for a given soil type and soil area. (3) That the conductivity of soils saturated with water increases directly as the amount of salt in solution increases; below saturation, the resistivity increases almost in proportion to the surface area of the soil, at saturation and beyond, the surface area does not exert so much influence. (4) That humus decreases the conductivity of a soil.

A sandy soil will probably afford least electrolyte, and clay soil most, due mainly to the state of physical division of the soil. It would be possible to roughly calculate the electrolysis produced by a given potential difference between two points in the soil. R. O. E. D.

MINERALOGY.—*Die chemische Zusammensetzung von Jamesonit und Warrenit.* W. T. SCHALLER. Zeitschr. Kryst. Mineral, **49**: 562–565. 1911.

From a review of the literature it is concluded that the formula for jamesonite is $4PbS.FeS.3Sb_2S_3$ while warrenite is a mixture of jamesonite and zinckenite. W. T. S.

MINERALOGY.—*An occurrence of strüverite.* FRANK L. HESS and R. C. WELLS. American Chemical Journal, **31**: 432–442. 1911.

The mineral here designated strüverite is one of a series containing TiO_2, FeO, Ta_2O_5 and Cb_2O_5, in variable proportions. At one end of the series is a group to which the name ilmenorutile is given, in which Cb_2O_5 exceeds Ta_2O_5. At the other end of the series is a group in which the Ta_2O_5 exceeds the Cb_2O_5 and of which the mineral described in the paper is the only representative known. In 1908 Prior and Zambonini[1] described a mineral with a nearly medial composition, which they called strüverite, and defined in such a way as to include

[1]On strüverite and its relation to ilmenorutile. Mineralog. Mag., **15**: 78-89. 1908.

and anticipate the discovery of minerals in which Ta_2O_5 was in excess of Cb_2O_5. To avoid confusion the name is retained.

The mineral here described is found in considerable quantity as an original constituent of the Etta granite pegmatite dike near Keystone, South Dakota. It is black, opaque, and crystallizes in the rutile group of the tetragonal system. It occurs as individual crystals, the largest of which are 1.8 to 2 mm. across, by 5 mm. long, and in aggregates up to 16 mm. across. The analysis was made by decomposing the mineral with chlorine and sulphur monochloride, and separating the chlorides thus obtained by fractional sublimation. The analysis gives the formula $Fe\,O.\,(Ta, Cb)_2O_5.\,6\,Ti\,O_2$ with 49.1 per cent TiO_2, 7.5 per cent FeO, 35.7 per cent Ta_2O_5, 6.4 per cent Cb_2O_5 and 1.3 per cent SnO_2 (probably replacing TiO_2). R. C. W.

GEOLOGY.—*Geology and ore deposits of the Breckenridge district, Colorado.* F. L. RANSOME. Prof. Paper U. S. Geological Survey No. 75. Pp. 184, with maps, sections and illustrations. 1911.

The Breckenridge district is in Summit County, Colorado, 60 miles west-southwest of Denver. The fundamental rocks are granites and schists of pre-Cambrian age. The thick series of Paleozoic rocks present in the Leadville and Tenmile districts thins to the north and west and is not represented near Breckenridge, where the oldest sedimentary rocks, resting directly on the pre-Cambrian, are the red sandstones and shales of the "Wyoming" (Triassic?) formation. Apparently conformable above them is the Dakota, overlain in turn by a thick formation of dark hales which probably represent the Benton, Niobrara, and part of the Montana formations of the Upper Cretaceous. In the northern part of the district the Dakota rests on the pre-Cambrian. The sediments are intruded by monzonitic porphyries ranging in composition from siliceous quartz monzonite porphyry to hypersthene-bearing diorite porphyry. The Quarternary deposits may in part be divided into glacial accumulations of Pleistocene age and stream gravels of the recent epoch. There were two advances and retreats of the ice. The earlier is represented by terrace gravels and what has been called older hillside wash; the latter by moraines and low-level gravels or valley trains.

The principal fissures strike northeast and form a conjugate system. No single fissure is known to exceed 1700 feet in length and none was formed to the accompaniment of important structural displacement. The ore deposits may be grouped as (1) veins of the zinc-lead-silver-gold series, (2) stockworks and veins of the gold-silver-lead series, (3)

gold veins of Farncomb Hill, (4) veins in the pre-Cambrian rocks, (5) metasomatic replacements along bedding planes, and (6) gold-silver deposits in Dakota quartzite. The Breckenridge ores were deposited through the agency of thermal waters and gases given off from a solidifying monzonitic magma and perhaps coöperating with water of atmospheric or of less definitely assignable origin. Whether the metals in the ores came from the magma or from the rocks invaded by it is not known. The principal gaseous constituents of the magmatic waters were hydrogen sulphide and carbon dioxide.

The ores were probably deposited in early Tertiary time and were enriched throughout the later Tertiary. The character of the deposits is notably dependent on the kind of country rock.

Most of the mines show a decrease in the proportion of galena with augmented depth, which means in general a depreciation of the ore. Lead ores of shipping grade probably nowhere in the district extend to a depth of much more than 300 feet. The downward change in the character of the ores indicates enrichment. A large part of the galena in the district is believed to have been concentrated by downward-moving atmospheric water.

There are three general classes of gold placers—(1) the bench or high-level placers; (2) the deep or low-level placers; and (3) the gulch washings. The gulch washings were the first worked and yielded much gold to the pioneers in the district. The most noted placers of this group were on the slope of Farncomb Hill. The bench placers are in the terrace gravels and older hillside wash. They have been extensively worked in the past by hydraulic methods, but were not being exploited in 1909. They are generally of low grade. The deep placers, in the low-grade gravels, occupy the bottoms of the present valleys and are now being worked by dredging. The pay channels are from 180 to 400 feet wide and average locally up to about 50 cents a cubic yard; but much of the material does not yield 20 cents a yard. F. L. R.

BOTANY.—*Crown-gall of plants: Its cause and remedy.* ERWIN F. SMITH, NELLIE A. BROWN and C. O. TOWNSEND. Bulletin Bureau of Plant Industry, Department of Agriculture, No. 213. Pp. 215, pls. 36. 1911. *Crown-gall and sarcoma.* ERWIN F. SMITH. Circular Bureau of Plant Industry No. 85. Pp. 4. June 20, 1911.

Bulletin 213 deals with a widely distributed and harmful disease of orchard trees and other plants. This disease is commonly known in the United States as crown-gall, but it may occur not only on the crowns of plants, but on roots and shoots.

The disease has been known for a long time, and under the supposition that it was infectious and injurious various States have made quarantine laws against it. The disease has been ascribed to various causes, without satisfactory proof, and many persons have been led to believe that it was not due to any organism. The experiments detailed in the Bulletin show clearly that the gall is due to bacteria and is infectious, being readily transmitted not only from plant to plant of the same kind, but also to many plants of widely different families. The Bulletin shows that the growth is not only of itself injurious to the plant, but also may form an open wound through which other parasites are likely to enter, such as the fungus of root rot, and the bacteria which cause blight of apples and pears.

The Bulletin recommends that the inspection laws now in force in the various States be continued and enforced. It shows what plants it is not advisable to use as a crop following a galled one. It describes the life history and cultural characters of the organism involved; points out the difficulties attending its isolation and identification; gives numerous illustrations showing the nature of the tumors produced and the time involved in their production when pure cultures of the organism were used; shows that the organism has a wide range of host plants, and that the overgrowths produced are in many ways anatomically and otherwise strikingly like those found in certain malignant animal tumors.

The bacteria causing these plant tumors are not abundant in the tissues, sometimes very rare; are hard to see and difficult to stain; they perish readily both in the tumor and in culture-media; are difficult to cultivate from the tissues unless one knows the technique; do not form abscess cavities after the manner of the tubercle diseases, but multiply in limited number within the tissues and apparently only inside the cells which their presence stimulates into rapid division. The disease forms secondary tumors readily, and on this account is cut out with difficulty.

The organism loses virulence easily both inside the tumors and in culture-media, and finally if the plants are not destroyed by it they seem to acquire a partial or complete immunity.

The Bulletin involves team work done by four people in the Department of Agriculture, covering a period of seven years and the total number of experiments involved amounts to thousands.

Circular No. 85 gives in outline the results of further studies on resemblances of crown-gall of plants to malignant animal tumors. Since Bulletin 213 was published it has been found that the primary tumors are connected to the secondary ones by means of a deep-seated strand of tumor tissue. This strand occurs in the inner wood or at the junction of wood and pith, and wedges apart the normal tissues of stem and leaves quite after the manner of a foreign body, giving rise in various places to the secondary tumors.

When the primary tumor occurs on a stem, secondary tumors frequently appear in the course of a few weeks or months at a considerable distance on leaves, and in this case the same thing happens as in metastasis of malignant animal tumors, viz., the structure of the secondary tumor is that of the primary tumor and not that of the tissue in which it is lodged. In other words, the leaf tumors of this derivation have the anatomy of the *stem*.

The bacteria occur within the multiplying tumor cells and it is through their action on the nucleus that these cells are compelled to divide and take on the abnormal rapidly multiplying tumor growth. The bacteria have been found (sparingly) in the secondary tumors and in the strands connecting these to the primary tumor. There is no reasonable doubt, therefore, that we have in this disease a type of cell multiplication closely parallel to that which occurs in malignant animal tumors.

Full details will be given in another bulletin as soon as the photomicrographic illustrations can be prepared. E. F. S.

FORESTRY.—*Windbreaks: their influence and value.* CARLOS G. BATES. Forest Service Bulletin No. 86. Pp. 106, with plates and diagrams. 1911.

Windbreaks may be used profitably in the middle west, the northern prairies, the lake states, the eastern states north of the forty-ninth parallel, the southwestern states, and in the fruit growing regions of the Pacific coast.

The distance at which the effect of a windbreak may be felt averages

twenty times its height, altho absolute protection of a crop such as corn, in a wind with a velocity of 50 miles an hour, can not be expected beyond a distance of from six to eight times the height of the windbreak. Partial protection is given over a distance of from twelve to fourteen times the height.

The efficiency of a windbreak in checking evaporation from the soil may, in extreme cases, amount to 70 per cent of the moisture ordinarily lost. Protection in this respect is appreciable for a distance equal to five times the height of the trees in the windward direction, and fifteen or twenty times the height leeward.

The effect of a windbreak upon temperature in the zone of its influence is much greater than is commonly supposed. The daily range of temperature in an area protected by a windbreak is nearly 9° F. greater than where the air circulates freely. The effect of the superheating of both air and soil in a protected zone is favorable to crops which must begin growth at a time when the heat is barely sufficient for germination. Corn and alfalfa are the field crops least affected by the shade from windbreaks.

Honey locust and osage orange are the trees adapted to windbreak planting which cast the heaviest shade. Cottonwood, maple, green ash, white cedar, and Scotch, Austrian, and white pine are those which cast the least.

The absorption of soil moisture by the roots in a windbreak may in the case of an orchard be appreciable, but need not result in real damage. Corn, oats, and wheat may suffer within 45 feet from the windbreak, but with care the effect is much less apparent. It may be greatly lessened by thorough cultivation of the soil near the trees, by planting tap rooted species in the windbreak, or by the use of seed crops next to the trees. There is little basis for the belief that windbreaks sap the fertility of the soil. The trees' use of soil moisture may, however, reduce the activity of the nitrifying bacteria and cause temporary sterility in the zone of root influence.

Cottonwood is the best tree for windbreaks in the middle west; Scotch pine, Norway pine, and Colorado blue spruce in the northern prairies; white pine in the lake and northeastern States; chestnut and yellow poplar in the central eastern States; osage orange in the southwest; eucalypts, Monterey cypress and Monterey pine in California; and poplars, willows, and cottonwoods in Washington and Oregon.

FINDLEY BURNS.

FORESTRY.—*Eucalypts in Florida.* RAPHAEL ZON. Forest Service Bulletin No. 87. Pp. 47, with plates. 1911.

Next to southern California, Florida promises most for the growing of eucalypts in the United States. The region in Florida in which eucalypts can be successfully grown may be roughly defined as the orange belt, about 40 per cent of the total area of the State. In all, about 16 species of eucalypts are growing in Florida today. Those which are especially well adapted to the climate are *E. resinifera, rostrata, viminalis, robusta,* and *tereticornis.* The planting is still in the experimental stage. If the species of eucalypts which are adapted to Florida can be economically grown on a large scale, and will yield durable ties, posts, and piles at an age at which the native trees hardly reach sapling size, they will prove of the great value to the State. There are available for experiment large areas in Dade, De Soto, Lee, Hillsboro, Pasco, Fernando, and Sumter Counties at present, which are not in a high state of productivity.

FINDLEY BURNS.

ZOÖLOGY.—*Anatomy and physiology of the wing-shell Atrina rigida.* BENJAMIN H. GRAVE, University of Wyoming. Bulletin of the U. S. Bureau of Fisheries, **29**: 409–440, pls. 48–50, figs. 15. 1911.

This study establishes the following points:

1. The arterial system of the two sides is not symmetrical.

2. The venous system lacks the "sinus venosus" which is commonly present in lamellibranchs and which receives the blood from all parts of the body previous to entering the kidney. This sinus or a substitute for it is a necessary part of the mechanism described by Menegaux for extruding the foot and other organs whose movement is due to blood pressure.

3. The blood which enters the gills must pass through a capillary system before emerging again.

5. There is no pallial line but the mantle is attached to the shell at a single point just ventral to the adductor muscle. As a consequence the mantle can be withdrawn a considerable distance from the edge of the shell. After being contracted the mantle again reaches the edge by creeping outward upon the shell.

6. The spines on the outer surface of the shell are formed by little tongues of the mantle which creep out into them during their growth period.

7. The mantle gland which Menegaux calls the "appendice" is probably a "swab" for keeping the mantle free from dirt.

8. The kidney excretes vacuoles containing quantities of concretions, but little protoplasm and no nuclei are thrown off.

9. Each ganglion supplies a definite region of the body and there is little overlapping. Reflex arcs exist.

10. The otocyst is located in the end of the foot far from the pedal ganglion and is a variable structure, sometimes consisting of as many as eight lobes and sometimes of only one. In one instance three separate ciliated tubes connecting them with the outside were discovered. This indicates that they have arisen from three separate invaginations of the ectoderm. This is the first instance of this sort found in lamellibranchs above the protobranchia. E. M. SMITH.

CONCHOLOGY.—*Notes on California shells, II.* WM. H. DALL. National Museum. Nautilus, **24**: 109–112. 1911.

Miscellaneous notes on species represented in the National Museum and in various California collections. *Bathytoma tremperiana, Modiolus diegensis* and *Pachyonia inæquale* var. *spiratum* are described as new. PAUL BARTSCH.

CONCHOLOGY.—*Notes on California shells, III.* WM. H. DALL. National Museum. Nautilus, **24**: 124–127. 1911.

Miscellaneous notes on the distribution of many California species. PAUL BARTSCH.

CONCHOLOGY.—*Notes on Gundlachia and Ancylus.* WM. H. DALL. National Museum. American Naturalist, **45**: 175–189. 1911.

Biological notes bearing on the validity and relationship of the two genera, illustrated by a series in the National Museum. PAUL BARTSCH.

CONCHOLOGY.—*New species of shells from Bermuda.* WM. H. DALL and PAUL BARTSCH. Proceedings U. S. National Museum, **40**: 277–288, pl. 38. 1911.

An account of species collected in Bermuda and of which a series is in the National Museum. The following are described as new and mostly figured. *Mitra haycocki, Columbella somersiana, Aclis bermudensis, Turbonilla (Careliopsis) bermudensis, T. (Strioturbonilla) peilei, T. (S.) haycocki, Cerithiopsis movilla, C. ara, C. pesa, C. vicola, C. io, Fissuridea bermudensis, Odostomia (Chrysallida) nioba,* and *Ischnochiton (Stenoplax) bermudensis.* A list of the species not new is also given which contains several not previously reported from Bermuda. P. B.

CONCHOLOGY.—*Description of new mollusks of the family Vitrinellidae from the west coast of America.* PAUL BARTSCH. Proceedings U. S. National Museum, **39**: 229–234, pls. 34–40. 1911.

The following new species are described and figured: *Cyclostrema baldridgei, miranda, adamsi; Circulus liriope* and *diomedeæ* and *Cyclostremella dalli.* P. B.

CONCHOLOGY.—*The recent and fossil mollusks of the genus Alabina from the west coast of America.* PAUL BARTSCH. Proceedings U. S. National Museum, **39**: 409–418, pls. 61–62. 1911.

This paper is a monograph of the genus *Alabina* in which all the species known from the west coast are described and figured. The following are new: *Alabina barbarensis, hamlini, phanea diomedeæ ignati, monicensis, tenuisculpta diegensis,* and *tenuisculpta phalacra.* P. B.

FISHERIES.—*The migration of salmon in the Columbia River.* CHARLES WILSON GREENE. Bulletin of the Bureau of Fisheries, **29**: 129–148. Pls. 26–27. 1911.

On August 14, 1908, at the State fish hatchery at Chinook, Washington, there were liberated 25 chinook salmon, 16 silver salmon, and 18 steelheads which had been marked by means of an aluminum patent button clamped through the tail fin. Seventeen fish out of this total of 59 were retaken and reported, and upon their careers as indicated by place and date of capture are based the following conclusions, which, however, because of the preliminary nature and limited extent of the experiment, are presented as tentative: (1) Salmon may take from 30 to 40 days to pass through the brackish water within the limits of the fishing waters at the mouth of the Columbia River. (2) That salmon spend considerable time swimming back and forth in tide water during the acclimatization to fresh water is indicated (a) by the fact that two fishes were taken below the point at which they were marked, (b) by the corrosion of the aluminum marking buttons by salt water, and (c) by the long time spent by certain fishes in reaching the lower limits of fresh water. (3) When wholly within fresh water, the silver salmon and the steelhead make the migratory journey at an average speed of from 6 to 7½ miles a day and probably more. (4) There is little evidence that the process of marking or that partial obstruction of the course by fishing gear does more than produce a temporary checking of the migratory journey. E. M. SMITH.

FISHERIES.—*Condition and extent of the natural oyster beds of Delaware.* H. F. MOORE. Bureau of Fisheries Document 745. Pp. 30, 1 chart. 1911.

The State of Delaware, following the example of various other oyster producing States, recently solicited a Federal survey of her natural oyster grounds in Delaware Bay. Dr. Moore, representing the Bureau of Fisheries, was in charge of the work, which had for its specific purpose the accurate location and charting of the natural oyster beds and investigation of their present condition and productiveness.

Of the 16,435 acres (over 25 square miles) explored with sounding lines and chains, 2,144 acres were found to be included in areas of varying degrees of productiveness. These represented a total oyster content estimated after careful examination to be 189,035 bushels. Each bed is described and details of the examinations are tabulated to show dense, scattering, very scattering and depleted areas in each case, the number of each kind of oysters (seed and market) actually caught per square yard, and the estimated content per acre.

Tides, currents and salinity of the water were noted, as was also the presence of probability of enemies of the oyster. Of these the drill was found to be the most destructive in this region.

The chart accompanying the report is of large size and replete with data as to character of oyster growth, depths and character of bottom, in addition to accurate delineation of the oyster beds. E. M. SMITH.

PHARMACOLOGY.—*The effects of a number of derivatives of choline and analogous compounds on the blood pressure.* REID HUNT and R. DE M. TAVEAU, Hygienic Laboratory, U. S. Public Health and Marine-Hospital Service. Bulletin of the Hygienic Laboratory, No. 73. 1911.

This bulletin discusses the methods of preparation and the physiological action of 79 compounds related to choline; most of them had not previously been made. Some of these substances have more pronounced effects upon the circulation than any drugs previously known and it is probable that some of them will ultimately prove of practical importance. The relation between the chemical constitution and the physiological action of the members of this group of compounds was studied as the basis for further work in the search for useful remedies. R. H.

PHARMACOLOGY.—*Digitalis standardization and the variability of crude and of medicinal preparations.* WORTH HALE, Hygienic Laboratory, U. S. Public Health and Marine-Hospital Service. Bulletin of the Hygienic Laboratory, No. 74. 1911.

Digitalis is one of the most important drugs in the Pharmacopœia, but, unfortunately, it is of very variable activity; this bulletin discusses, in detail, some of the causes of this variability. The influence of the age of the leaves (whether of the first or second year growth), the methods of drying and preserving, and the effect of cultivation, are discussed; also the variations in the strength of official preparations, the relative strength of fluid ext acts and tinctures, and best methods of insuring preparations of uniform activity. A number of special preparations such as triturates, tablets, and certain proprietary preparations were also examined. W. H.

PHARMACOLOGY.—*Digest of comments on the Pharmacopœia of the United States of America (eighth decennial revision) and the National Formulary (third edition) for the calendar year ending December 31, 1908.* MURRAY GALT MOTTER and MARTIN I. WILBERT, Hygienic Laboratory, U. S. Public Health and Marine-Hospital Service. Bulletin of the Hygienic Laboratory, No. 75, 1911.

The present bulletin is the fourth of the series of "Digest of Comments" on the Pharmacopœia of the United States and the National Formulary, the two books recognized by the Food and Drugs Act of June 30, 1906, as the standard with reference to the identity, purity and strength of the medicaments therein described.

All of the available publications, containing matter of interest to the revisers of the Pharmacopœia and the National Formulary, have been reviewed and practical suggestions and references, bearing on the improvement of the two books as standards under the law, are presented in as concise a form as possible.

Apart from their use by the members of the several Committees of Revision these bulletins are of value as a résumé of current literature on the scope and content of the Pharmacopœia and the National Formulary, and on the nature, origin and uses of the various substances used in the treatment of disease.

Considerable space is given to the discussion of the possible development of international standards for potent medicaments, and the gradual compliance of foreign Pharmacopœias with the provisions of the treaty signed at Brussels in 1906 is noted. M. G. M.

BACTERIOLOGY.—*Abortive cases of poliomyelitis; an experimental demonstration of specific immune bodies in their blood-serum.* JOHN F. ANDERSON and WADE H. FROST, Hygienic Laboratory, U. S. Public Health and Marine-Hospital Service. Journal of the American Medical Association, 56: 663–667. 1911.

This paper gives the results of a series of experiments to demonstrate the existence of abortive cases of poliomyelitis or infantile paralysis by making use of the serum of recovered cases of this disease to neutralize the virus of poliomyelitis. It was found that the clinical diagnosis of abortive cases of poliomyelitis was confirmed by laboratory experiments in 66 per cent of the cases studied. These findings have a most significant bearing on the diagnosis and epidemiology of acute anterior poliomyelitis. J. F. A.

BACTERIOLOGY.—*Experimental measles in the monkey: a preliminary note.* JOHN F. ANDERSON and JOSEPH GOLDBERGER, Hygienic Laboratory, U. S. Public Health and Marine-Hospital Service. Public Health Reports, 25: 847. 1911. *Experimental measles in the monkey: a supplemental note.* JOHN F. ANDERSON and JOSEPH GOLDBERGER. Ibid. 25: 887. 1911. *The period of infectivity of the blood in measles.* JOHN F. ANDERSON and JOSEPH GOLDBERGER. Journal of the American Medical Association, 57: 113. 1911.

Previous to the appearance of these brief papers, various investigators had reported that the monkey was not susceptible to measles. The authors, however, have shown that the monkey is susceptible to measles by inoculation of the blood or of the nasal and buccal secretion from human cases of measles. Further, that when a well monkey is placed in the cage with a monkey suffering from measles the former contracts the disease after the usual incubation period. It is believed that the results reported in these papers mark an important advance in our knowledge of the etiology of measles. It is hoped that further work may definitely determine the cause of measles and the means of its transmission and methods by which the disease can be prevented. J. F. A.

SANITATION.—*Sewage pollution of interstate and international waters, with special reference to the spread of typhoid fever. I.—Lake Erie and the Niagara river.* ALLAN J. MCLAUGHLIN, Hygienic Laboratory, U. S. Public Health and Marine-Hospital Service. Bulletin of the Hygienic Laboratory, No. 77. 1911.

This is the first of a series of papers which it is contemplated to present for publication on the problem as it affects certain international

and interstate waters. The investigation was begun on the Great Lakes because of the industrial and commercial importance of the lake cities and the spread of typhoid fever by means of the enormous interstate traffic for which these cities are responsible. A. J. McL.

ENGINEERING.—*The expansion and contraction of concrete while hardening.* A. T. GOLDBECK, Office of Public Roads. Proceedings of the American Society for Testing Materials, II: 1911.

This paper presents the results of micrometer measurements taken on concrete while hardening. The specimens were 8 inches by 8 inches in cross-section with a gage length of 50 inches. They were mixed in different proportions, with varying percentages of water and were stored under different conditions of moisture. Quantitative results of the shrinkage in air and expansion while moist are shown graphically, the initial measurements having been taken when the specimens were one day old and continued at regular intervals. A. T. G.

ENGINEERING.—*Bituminous dust preventives and road binders.* PREVOST HUBBARD, Office of Public Roads. Yearbook of the Department of Agriculture, 1910. 1911.

The author, after mentioning bitumens as the most important class of materials employed as dust preventives and road binders, divides them into two main classes: (1) Native bitumens, (2) Artificial bitumens. The treatment of the former for the purpose of making them suitable for use on roads is briefly discussed, as is also the relative value of different bituminous distillates and residues. This is followed by a classification of bituminous materials with regard to their value as "dust preventives" or as "road binders." The conditions affecting the selection of material are briefly outlined, followed by a description of the two principal methods of application—the penetration method and the mixing method. The author also briefly describes the character and method of application of rock asphalt and manufactured bituminous aggregates. C. S. REEVE.

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

WASHINGTON ACADEMY OF SCIENCES

At the 66th meeting, at the Cosmos Club, January 5, 1911, Dr. JOHN A. BRASHEAR delivered an address on *The contributions of photography to stellar research.*

The author discussed in a clear and charming manner many of the contributions that photography has made to our knowledge of astronomy and illustrated each with beautiful pictures.

The 67th meeting, at the Cosmos Club, 4:40 p.m., January 19, 1911, was for the transaction of routine business and the election of officers for the ensuing year, as follows: *President,* F. W. Clarke; *Non-resident Vice Presidents,* T. C. Chamberlin, H. F. Osborn; *Corresponding Secretary,* Frank Baker; *Recording Secretary,* W. J. Humphreys; *Treasurer,* A. L. Day; *Resident Vice Presidents,* nominated by the affiliated societies; Anthropological Society, Walter Hough; Archaeological, Mitchell Carroll; Biological, David White; Botanical, W. E. Safford; Chemical, H. W. Wiley; Engineers, M. O. Leighton; Entomological, A. D. Hopkins; Foresters, Gifford Pinchot; Geographic, Henry Gannett; Geological, A. H. Brooks; Medical, W. M. Barton; Historical, J. D. Morgan; Philosophical, Lyman J. Briggs.

At the 68th meeting, at the Cosmos Club, January 19, 1911, Dr. F. M. JAEGER, Professor of Chemistry in the University of Gröningen, Holland, spoke *On doubly-refracting liquids and the so-called liquid crystals.*

The subject of "liquid crystals" and "anisotropic liquids" is one of experimental research and also of theoretical speculation, and has a most important significance for both chemistry and physics, since it is fundamental to our theoretical ideas on the real nature of liquids.

When we ask ourselves how far it is right to speak of "liquid crystals, we can treat the question from two sides: First, as to how far liquids can exhibit properties that have seemed to be typical of "crystalline" matter; and second, to what degree crystals can share the characteristics of a "liquid" in the common sense of the word.

The typical property of crystalline matter is its anisotropy, or the rigorous dependence of the physical properties of crystals on the special direction in which those properties are observed. In most cases such media are *optically* anisotropic, a condition that insures the easiest and most certain detection and measurement of this property.

It is well known that true liquids can become birefringent under the

influence of mechanical deformation, as demonstrated by Maxwell, Mach, de Metz, and others; under dielectric stress, as shown by Kerr, and also, according to Majorana, in strong magnetic fields.

In all these cases the common point is that the birefringence disappears always with the external forces which produced it—with most liq ids instantly, with some gradually. The time required for the birefringence to fall to the $1/\epsilon$ part of its original value has been defined by Maxwell as the "time of relaxation," and is directly proportional to the internal friction. The time of relaxation has never been found greater than one and one-half hours, and this is much reduced with a slight increase of temperature.

It might be supposed that liquid crystals are only liquids of very long relaxation periods, but this view is not supported by accurate measurements of viscocity nor does it agree with the observed close analogy between the birefringent and the ordinary isotropic liquids. On the other hand, it is a well known fact that crystals can be plastic to any degree. In fact the possibility of deforming crystals without destroying them is of the highest practical importance in drawing and forging metals and their alloys as Ewing, Rosehain, and others, have demonstrated with the microscope. We might therefore ask what manner of substance is a crystal that shows such a high degree of plasticity?

Consider, for instance, the needle-like crystals that form on the carbon plates of exhausted Leclanché cells, and have the composition $ZnCl_2 + 2NH_3$. These can be wound spirally around an ordinary lead pencil without breaking them or destroying their orthorhombic character. Experiment shows that they possess one or more systems of so-called "gliding planes" along which the molecules roll and glide, under the influence of feeble forces, incomparably more easily than along any other plane. The deformation of the crystal in these cases is called "singular deformation along gliding planes" and does not alter the internal structure. Exact investigations have shown that the original symmetry of the molecular aggregation remains wholly intact. A deformed crystal of barium bromide, for instance, will continue growing in its saturated solution and become a quite normal individual, which would be impossible if the molecular arrangement of the crystal had been modified during the deformation. Crystals may have a number of gliding planes; those of the Leclanché cells have six, situated in two different zones. Crystals can thus be deformed without alteration of their internal molecular structure, and this deformation can take place in several directions at the same time, and the crystals therefore be highly plastic.

Suppose we had a crystal of this kind whose molecules roll so easily along a number of such gliding planes that even a weak force like gravitation is sufficient to move them; it would be deformed under its own weight without any change of internal structure—the crystal would "flow." Looked at in this way the expression "fluid crystal" loses its seeming absurdity. Such crystals exist and are closely related to ordinary crystals from which they differ only in having a much smaller rate of recovery after deformation. and a preponderant surface tension.

Fluid crystals, like ordinary crystals, possess form, elasticity, surface tension and molecular vector forces. Presumably, therefore, a real distinction exists between these fluid crystals and the true "anisotropic liquids," like *p*-azoxyphenetol, for here no trace of form elasticity remains. The numerous transitions of these latter and their whole physico-chemical behavior are quite analogous to those of fluid crystals, but their behavior under the microscope differs in so many respects from that of the true liquid crystals that their real nature is still enigmatic.

All substances showing the phenomena of fluid crystals, or anis tropic liquid phases, behave exactly like polymorphic substances. All the transition phenomena shown by these compounds during the gradual rise or fall of temperature of the system can be explained in just the same way as in the case of polymorphic substances undergoing a series of phase-transitions. Even the same two kinds of polymorphic transformations, the "enantiotropic" (reversible) and the "monotropic" (irreversible) are met with again here; and just as there are substances with two, three, four and more different solid polymorphic modifications, so there are substances which exhibit two, three, four or more liquid states. The liquid which appears last, or at the highest transition temperature, is always the isotropic one; the others are turbid-looking aggregations of fluid crystals, and notwithstanding the fact that they are stable at *lower* temperatures, the fluid crystals are often of *much lower* viscosity than the isotropic liquid. Fluid crystals are true homogeneous phases as has been proved in a number of ways.

All anisotropic liquid phases have a *turbid* appearance. They look as if they were emulsions like oil and water. However, this appearance of turbidity is not at all indicative of a close analogy to emulsions, but is a necessary consequence of the particular structure of these phases, for they are really aggregations of innumerable little fluid crystals each of which is completely transparent. These little crystals, like ordinary crystals, are birefringent, and when in great multitude and irregularly oriented must be turbid as a whole from the innumerable refractions and total reflections of the transmitted light at the boundaries between adjacent individuals.

It has been asked why liquid crystals do not flow together. Real liquids do so; but they possess no molecular *directive* force. On cooling, an isotropic liquid is transformed into an aggregation of liquid crystals and not into a single one, for the same reason that a molten substance never solidifies to one big solid crystal but always to a turbid aggregate made up of a great number of irregularly oriented crystals.

The strange and disturbing phenomena which are displayed by fluid crystals and in particular this misunderstood turbidity, have led some to suppose that these substances are not pure compounds but are mixtures of imperfectly miscible liquids. To be sure, liquid emulsions feebly depolarize transmitted light; but they can never account for the systematic variation of the enormously strong birefringence with the direction of transmission through these flowing bodies—a birefringence which is, in some cases, several times that of calcite. And there are many other

properties, such as pleochroism, magnetic induction, and discontinuous phase transition, which can not be explained in this way. In short numerous physico-chemical researches have proved beyond doubt that fluid crystals are simple homogeneous phases of well defined chemical compounds.

The lecture was accompanied by experiments and illustrated by a number of slides that made the speaker's meaning clear and his argument convincing.

At the 69th meeting, in the Cosmos Club, February 1, 1911, Dr. W. D. BANCROFT, Professor of Physical Chemistry, Cornell University, presented *A universal law*. Reported in *Science*, **33**: 436. 1911.

At the 70th meeting, in the National Museum, March 25, 1911, Dr. SVANTE ARRHENIUS, Director of the Nobel Institute, Stockholm, Sweden, spoke on *The atmospheres of the planets*. Reported in *Science*, **33**: 632. 1911.

At the 71st meeting, in the Cosmos Club, March 30, 1911, Dr. VICTOR GOLDSCHMIDT, Professor of Mineralogy in the University of Heidelberg, Germany, lectured on *The nature of crystals*. Reported in *Science*, **33**: 870. 1911.

At the 72d meeting, in the National Museum, April 18, 1911, SIR JOHN MURRAY delivered an illustrated address on *The ocean*. Reported in *Science*, **33**: 870. 1911.

The 73d meeting was held on the steamer *Southland*, en route to the Dismal Swamp, April 28, 1911. The following addresses were delivered: *Geography and geology of the Dismal Swamp*, E. W. SHAW; *Peat deposits*, C. A. DAVIS; *The forest types in the Dismal Swamp*, R. ZON; *Plant life in the Dismal Swamp*, F. V. COVILLE; *Ground animals of the swamp*, F. W. TRUE; *The birds of the swamp*, C. HART MERRIAM. Reported in *Science*, **33**: 909. 1911. W. J. HUMPHREYS, *Recording Secretary*.